TF ANSA NS

PROCEEL

I THE

NEW ZEALAND ITUTE

VOL. 59

(0 VI I F I I I I

Part 1 MARCH, 1928

)f \ / Z I d

U TE

EDITED AND PUBLIS ED UNDER THE AUTH( )st
OF GOVERNORS OF THE INST

ISSUED 31st MAY, 1928

Wellington

FERG) BOI

CONTENTS.

Part 1, 1928.

LIST OF PLATES.

PROCEEDINGS
OF THE
NEW ZEALAND INSTITUTE,
1928.

MINUTES OF ANNUAL MEETING OF THE BOARD OF GOVERNORS,

26th JANUARY, 1928.

The Annual Meeting of the Board of Governors of the New Zealand Institute was held in Victoria University College, Wellington, at 10 a.m. on Thursday, 26th January, 1928

Present.— Representing the Government: Mr. B. C. Aston (President); Dr. C. Chilton, Dr L. Cockayne, and Dr. J. A. Thomson.

Representing Auckland Institute: Professor H. W. Segar and Professor F. P. Worley.

Representing Wellington Philosophical Society: Mr. G V. Hudson.

Representing Philosophical Institute of Canterbury: Professor C. Coleridge Farr, and Mr. A. M. Wright.

Representing Otago Institute: Professor J. Park and Hon. G. M. Thomson, M.L.C.

Representing Nelson Institute: Professor Easterfield.

Representing Hawke's Bay Philosophical Institute: Mr H. Hill.

Representing Manawatu Philosophical Society: Mr. M. A. Eliott, Hon. Treasurer.

The Hon. Editor, Mr. J. C. Anderson, and the Hon. Secretary, Dr. P. Marshall, were also present.

Apologies for absence.—Apologies were received from His Excellency the Governor-General, and from Professor Kirk. Later apologies were also received from the Right Hon. the Prime Minister, and from the Acting Hon. Minister of Internal Affairs.

Presidential Address.—The President read his address, the meeting standing while he read the names of the Members and Honorary Members who had died during the year. Professor Farr moved and Mr. Hudson seconded that the President be thanked for his address, and that he allow it to be printed in the *Transactions of the New Zealand Institute.*

Fellowship Election and so on.—The election of two Fellows was then proceeded with and the President announced that Dr. H. H. Allan, of Feilding, and Professor J. A. Bartrum, of Auckland, had been duly elected.

Number of Fellows to be elected in 1929.—On the motion of Dr. Cockayne seconded by Mr. Hill it was resolved that two Fellows be elected in 1929.

Hector Award.—The President announced that the report of the Hector Award Committee was not available, and moved that the receipt of the report and action on the same be delegated to the Standing Committee. This was seconded by Mr. Eliott and carried.

Amount of Prize.—On the motion of Dr. Cockayne seconded by Mr. Hudson it was resolved that the amount of the Hector Prize for 1928 be £50.

Election of Honorary Members.—The Returning Officer reported that the following had been elected: Dr. J. S. Haldane, Dr. A. W. Hill, Sir David Orme Masson, Sir John Russell, Professor A. C. Seward, Professor J. Arthur Thomson.

Vacancies in Honorary Membership.—It was announced that Professor Sars and Professor Liversidge had died during the year, and two vacancies were thus created.

Reports of Incorporated Societies.—The reports and balance sheets of the following societies were laid on the table and referred to the Hon. Treasurer for inspection and report:—

Auckland Institute for year ending 8th February, 1927.
Wellington Philosophical Society for year ending 31st October, 1927.
Philosophical Institute of Canterbury for year ending 31st October, 1927.
Otago Institute for year ending 30th November, 1927.
Nelson Institute for year ending 31st October, 1927.
Hawke's Bay Institute for year ending 31st December, 1927.

REPORT OF STANDING COMMITTEE

FOR THE YEAR ENDING 31st DECEMBER, 1927.

MEETINGS.—During the year seven ordinary meetings and one special meeting of the Standing Committee have been held, the attendance being as follows: Mr. B. C. Aston, Wellington, 8; Mr. G. V. Hudson, Wellington, 8; Professor Kirk, Wellington, 5; Hon. G. M. Thomson, Dunedin, 4; Dr. Thomson, Wellington, 4; Dr. Cockayne, Ngaio, 3; Mr. A. M. Wright, Christchurch, 2; Mr. M. A. Eliott, Palmerston North, 2; Professor Segar, Auckland, 1; Professor Easterfield, Nelson, 1; Professor Farr, Christchurch, 1; Professor Park, Dunedin, 1; Mr. H. Hill, Napier, 1; Hon. Secretary, Wellington, 6; Hon. Editor, Wellington, 5.

PUBLICATIONS.—The year has been an exceptionally heavy one as far as publications are concerned. Volume 57 (the largest volume of *Transactions* yet published, having 1,133 pages of type and 80 pages of plates) was issued on the 10th March, 1927. It was laid on the tables of the House of Representatives and of the Legislative Council on the 15th July, 1927. The fifth part of Dixon's Bulletin on the Bryology of New Zealand was issued on the 7th July, 1927. The Reference List of Scientific Periodicals compiled for the New Zealand Institute by Mr. Gilbert Archey, of Auckland Museum, was issued on the 10th August. The 1st and 2nd part of the 58th volume of the *Transactions* was issued on the 17th August, the 3rd part on the 15th November, and the 4th part is in the press and will be ready in February. In addition a four-page circular, advertising the publications of the New Zealand Institute and the Philosophical Institute of Canterbury was printed.

Two thousand five hundred copies of this circular are being distributed by our London Agents, and it is hoped will be productive in increasing the sales of publications on hand.

Printing Matters.—Taking into consideration the fact that Volume 57 was the initial volume for the new printers, Messrs. Ferguson and Osborn, Ltd., that it was considerably larger than any previous volume, and that many papers required special hand-setting, the publication of this volume reflects very creditably indeed on the printers. In one or two instances the plates produced were not of a very high order, and this matter was taken up with Mr. Osborn who showed himself very ready to go thoroughly into the matter and to give entire satisfaction in every way, with the result that in the subsequent volume little fault is to be found.

In Volume 57 the printers had some difficulty, owing to indistinct MSS. and they have stipulated that in future all copy must be typewritten if required

A revised contract for a term of three years for the printing of the *Transactions* was entered into with Messrs. Ferguson and Osborn, Ltd.

A progressive step has this year been taken in that the *Transactions* are now issued quarterly. The Hon. Editor in his report has pointed out the advantages of this step, which apparently is meeting with general approval.

The price of the quarterly parts has been fixed at 10/- each, the double part Volume 58, Parts 1 and 2 at 15/-.

Author's Corrections.—Before their papers were accepted for publication in Volume 57 authors were informed by the Hon Editor that in future they were liable for all corrections over and above 2 per cent. of lines A good deal of objection has been raised by some authors in regard to this charge, but the Standing Committee at a meeting on the 22nd April passed a resolution: "That any author who failed to pay for his corrections will not have any further paper accepted by the Institute for publication"

Advertisements. A suggestion was made that approved advertisements might be accepted for insertion on the spare pages and inside cover of the *Transactions* An agent was seen regarding the matter, but owing to the small New Zealand circulation and limited scope of the advertisements it was not considered a payable proposition.

Government Printer's Charges. At last Annual Meeting a resolution was passed: "That in view of the fact that the price charged by the Government Printing Office for printing the *Transactions* has been greatly in excess of that now charged by a private printing firm, the Minister be asked to look into the amount debited to the Institute by the Government" This resolution and a copy of the detailed account for Volume 57 was sent to the Minister, who replied by pointing out that the work could have been done better and cheaper in the Government Printing Office, and he gave an estimate as to what the volume would cost if printed there

A comparative analysis of this estimate and the prices charged for previous volumes of *Transactions* was made out and forwarded to the Minister in support of the foregoing resolution, but no reply has been received.

Levy.—At a meeting of the Standing Committee, held on the 22nd April, it was resolved that the levy for incorporated societies for Volume 57 be 5/- each volume. The levy for Volume 58 has not yet been fixed.

Contributions As the result of an appeal for assistance in publishing in the *Transactions* papers of officers of their Departments, the Scientific and Industrial Research Department contributed £36, and the Cawthron Institute £15.

Reference List of Periodicals.—On the 1st March it was resolved to proceed with the printing of the Reference List. The printing was done by Messrs. Ferguson and Osborn, Ltd., and the list was issued in August. Already it has proved useful to Librarians and research workers and members generally, and 124 copies have been sold. As the list was some time in the course of preparation, it was felt that it would be wise to bring it

up to date and publish a supplementary list of additions and corrections to the publications already listed and also include some small departmental libraries which were not in the original list. A good deal of matter is already in hand and will be published at an early date.

Sales.—Over £53 has been raised during the year by the sale of *Transactions.* The sale of Maori Art has fallen off, and very few Bulletins have been sold. It is hoped that the advertising circular distributed by Wheldon and Wosley will have a marked effect on this source of revenue.

Partial Sets.—Donations of partial sets of *Transactions* have been made to the Martinborough Public Library, the Teachers' Library, Wanganui, the Training College, Wellington, the School of Maori Arts, Rotorua, and the Wellington Branch of the New Zealand Educational Institute.

Exchange List.—The following have been added to the Exchange List:—
Musei di Zoologia e Anatomia Comparata della R. Universita di Geneva.
Société Entomologique de Russie, Leningrad.
State University, Voronesh.
Ichthyological Laboratory, Kerch.
University of Central Asia.
Society of Naturalists, Kiev.
Science Society of China.

Library.—The Library is expanding rapidly—not only are new exchanges coming in, but back numbers of sets are being received from some of these and an endeavour is being made preparatory to binding to obtain missing numbers in certain series. The Library is beng used a great deal more than formerly, and the staff and certain students of Victoria College are finding it extremely useful in their work.

The Reports of the British Association for the Advancement of Science have not been received since 1918 when the Association ceased sending its Report on exchanges. It is very desirable that the New Zealand Institute Library should have a complete set of these Reports, and the gift from any members would be greatly appreciated.

Incorporated Societies.—The following reports and balance sheets have been received, and are now laid on the table:-
Philosophical Institute of Canterbury year ending 31st October, 1927.
Wellington Philosophical Society year ending 31st October, 1927.
Otago Institute year ending 30th November, 1927.
Auckland Institute year ending 8th February, 1927.
Nelson Institute year ending 31st October, 1927.
Hawke's Bay Philosophical Institute year ending 31st December, 1927.

The Hon. Treasurer on the 17th August forwarded a report showing the position of incorporated societies at the end of last year.

End of Financial Year.—At last Annual Meeting it was resolved that incorporated societies should be asked to end their financial year on the 31st October. The Philosophical Institute of Canterbury and the Nelson Institute already ended their year on that date. The Wellington Philosophical Society agreed to do so, and the Otago Institute will fall in line with other societies. The Hawke's Bay Philosophical Institute has not replied, and the Auckland Institute, as it receives the major part of its revenue from the Auckland City Council has to make its year coincide with that of the Council which ends on the 31st March.

Date of Annual Meeting.—It has been felt by many that January is a most inconvenient time to hold the Annual Meeting of the Board, and that an endeavour should be made to bring the Institute's financial year into line with the Governmental year. At its meeting of the 1st December the Standing Committee resolved to recommend to the Annual Meeting of the Board of Governors that future meetings be held in winter, and suggested May as a suitable time.

Hector Award.—As the Hector Award Committee was unable to make its report to the last Annual Meeting, owing to the absence of one of its

members, the Standing Committee was authorised to make the Award. At a meeting of the Standing Committee on the 22nd April the Hector Award Committee reported as follows:—

"We are of the opinion that the Award should be made to Professor C. A. Cotton, of Victoria College, Wellington. Professor Cotton has especially distinguished himself by his researches on the Geomorphology of New Zealand, and has added greatly to our knowledge of this subject. He is endowed with the capacity of recording his researches in a lucid style, and has a rare ability for illustrating his matter in drawings of great exactness and merit. We feel that Professor Cotton has done work that has given New Zealand a prominent place in the branch of study to which he has mainly devoted himself."

The Committee's Report was unanimously adopted, and at a meeting of the Wellington Philosophical Society on the 12th October at the Diamond Jubilee Celebrations the medal and Prize were presented to Professor Cotton by Mr. F. W. Furkert, President of the Wellington Philosophical Society.

Fellowship New Zealand Institute.—Mr. W. R. B. Oliver and Mr. H. D. Skinner were on the 12th May gazetted as Fellows of the New Zealand Institute.

Ten nominations were received for the Fellowship, and on the 25th July these were submitted to the Fellows for selection. On the 27th September the Hon. Returning Officer, Professor Segar, reported the result of the selection, and the four names were submitted to members of the Board on the 7th October. The election for two Fellows will take place at the Annual Meeting of the Board.

Fellowship Election.—The method of election as proposed by Professor Sommerville was considered by the Standing Committee and referred back to Professor Sommerville and Professor Segar for report.

National Research Council. The question of the formation of a National Research Council in New Zealand was discussed at length at last Annual Meeting, and certain recommendations which had been brought down by a sub-committee were approved, and it was finally resolved. "That a scheme for a National Research Council be tentatively approved by the New Zealand Institute and submitted to the Council of Scientific and Industrial Research and that the ultimate adoption of the scheme be contingent on the provision by the Government of the necessary finances for the functioning of the Council and for affiliation with the International Research Council." A copy of the recommendations and of the foregoing resolution were forwarded to the Secretary of the Scientific and Industrial Research Department who replied and asked that the President and Dr. Thomson should meet Professor Denham and Dr. Malcolm in regard to the subject.

On the 21st February the following letter was received from Dr Marsden addressed to the President:—

"Further to the conference between Professors Denham and Malcolm and yourself, Dr. Thomson and the writer, I have to inform you that the Research Council at its meeting on Thursday last considered the resolutions embodied in your letter of the 7th inst. with regard to the establishment of a National Research Council, and the following resolutions were passed:—

"1. That this Council is of opinion that there is no immediate necessity for the establishment of a National Research Council.

"2. That in order to take advantage of the scientific advice of the New Zealand Institute, wherever a local committee of the Research Council is established to supervise any investigations or researches, the local Philosophical Institute or New Zealand Institute be asked to nominate members to that committee.

"With regard to the latter resolution, I have to point out, for example, that the Council would appreciate the advice of your Institute on scientific questions at any time, and, in particular, it desires to thank you for nominating members to the Committees of the Apia and Hector Observatories, and, further, has to ask that the Otago Institute be requested to nominate two members to the following committee:—

"Committee on Food Value and Vitamins.

"Resolved: That a committee on Food Value and Vitamins be set up to carry on the work at Otago University on these subjects, and that £150 be provided in the Estimates to cover the Vitamin work, and that the Committee report on the financial requirements in regard to the former. That the Committee consist of Professor Malcolm, Professor Inglis, Mr. Bowman, and two nominees from the Otago Institute."

International Research Council.- On the 12th October, Dr. Marsden wrote as follows:—

"I shall be glad if you will place before your Executive the question of adherence to the International Research Council. This question was raised recently in connection with a desire that Dr. Thomson, Director of the Apia Observatory, Samoa, should attend the Prague Conference of the International Geodetic and Geophysical Union. The matter was considered by the Observatory Committee, on which your Institute is represented by four members, and, in the meantime, arrangements have been made by the Government for adherence to the International Research Council and the Geodetic and Geophysical Union, while the question of adherence to the Astronomical Union is also under consideration.

"I should be glad if you would place this matter before your Executive for an expression of its opinion.

"I enclose, for your information, copy of cable which has been forwarded to the High Commissioner for New Zealand; also copy of letter received from the Secretary for Lands and abstract from Minutes of the Apia Observatory Committee Meeting."

This letter was considered at a meeting of the Standing Committee on the 25th October. Mr. W. T. Neill, Surveyor-General, who was present by invitation, gave some additional information in regard to the fees of adherence to the Council and to the various Unions attached thereto. It was resolved that the President and Dr. Marshall interview Dr. Marsden on the subject and report to next meeting.

On the 1st December the President reported that Dr. Marsden stated that it was proposed to recognise the New Zealand Institute as the National Research Council for New Zealand and the Government would pay the necessary fees to the International Research Council through the New Zealand Institute, on the 3rd December, Dr. Marsden wrote to the Institute to this effect.

Research Grant Vote.- The research grant moneys are now received through the Department of Scientific and Industrial Research and applications for grants require to have the approval of the Council of that Department and not of the Hon. Minister of Internal Affairs as formerly.

A vote for research was placed at the disposal of the New Zealand Institute and applications were called for on the 27th May to be in by the 30th September. Nine applications for a total of £898 were received. Eight applications for a total of £813 were recommended by the Research Grants Committee and approved by the Standing Committee. The Council for Scientific and Industrial Research has not yet dealt with these publications.

Tongariro National Park: Amendment Act.—In accordance with a long standing request of the New Zealand Institute the Tongariro National Park Amendment Act includes a clause which now makes it possible for the Institute to elect its representative on the Park Board instead of its being represented by the the President *ex officio.*

Ohakune Track.- At a meeting of the Standing Committee on the 17th August the President reported that there was a proposal to widen the Ohakune Track, and that a sub-committee had recently visited the track to view the site. After some discussion the following resolution was passed:— "That the New Zealand Institute opposes any suggestion for widening the track from Ohakune to the Ohakune Hut, but suggests that the track from Ohakune Junction through the podocarp forest be improved without sacrificing any of the timber trees. The matter was brought up at the last meeting of the Tongariro National Park Board and deferred.

National Parks.—A letter was received from the Auckland Branch of the New Zealand Tourist League with reference to the conservation of National Parks. It was agreed to co-operate, and the President and the Hon. G. M. Thomson were appointed a committee to enquire further and to watch developments on behalf of the Institute.

Arthur's Pass.—The Annual Meeting last year authorised the Standing Committee to enquire regarding the practice of selling flowers in the National Reserve at Arthur's Pass. A resolution was forwarded to the Tourist and Lands Department, and the latter wrote stating that the Scenery Preservation Board had recommended that the land with the bush on it at Arthur's Pass be made a scenic reserve, and the necessary steps were being taken to carry out the recommendation.

Whitebait Fishery.—The Philosophical Institute of Canterbury wrote asking that the Institute endorse a resolution urging the Government to establish some form of control of the Whitebait Fishery. It was resolved: "That the New Zealand Institute represent to the Department of Scientific and Industrial Research and to the Fisheries Department the urgent need for close and continued research into the life-history of the whitebait in New Zealand and matters connected with the Whitebait industry and the taking of whitebait, and that it offers its services to assist in carrying out the work involved."

These Departments replied stating that the matter would receive consideration.

Type Specimens.—The matter was referred by last Annual Meeting to the Standing Committee with power to act. On the 22nd April the matter was discussed, and it was resolved that the following resolution, passed by a Conference of Museum Representatives is not feasible.—"That it is desirable that no Natural History Specimen should be exported from New Zealand for examination by scientists in other countries except under the condition that the type specimens of any new species be returned."

It was further resolved to agree to the following resolution passed at the same Conference: "That the Maori Antiquities Act should be amended to provide that Type Specimens of animals, plants, and fossils should not be exported from the country except on loan."

Science Congress.—At last Annual Meeting it was resolved that the next Science Congress should be held in Auckland in January, 1929. The Secretary of the Auckland Institute wrote stating that the Auckland Institute would undertake all arrangements for the Congress. The offer was gratefully accepted.

Australasian Association for the Advancement of Science.—Professor Kirk and Dr. H. G. Denham, of Canterbury, were appointed to represent the Institute at the Hobart Meeting of the A.A.A.S. on the 19th January, 1928.

(Pan) Pacific Science Congress.—The Fourth Meeting of the (Pan) Pacific Science Congress is to be held at Java in May-June, 1929, and the "First Announcement" has been received. Copies are available on application.

Celebrations.—During the year the Auckland Institute and the Wellington Philosophical Society celebrated Diamond Jubilees and successful functions were held. Invitations were also received from the American Philosophical Society to the 200th Anniversary of its foundation, and from the University of Toronto to its centenary celebration. Mr. H. D. Skinner, who was then in America, was asked if possible to represent the Institute at these gatherings, but he was unable to do so.

Carter Bequest.—With a view to carrying out a resolution passed at last Annual Meeting it was decided to ascertain from the New Zealand Astronomical Society whether, in the event of the Institute's being legally able to proceed in the direction proposed in the resolution, it would be willing

to provide for the upkeep and work of the Observatory. No reply has yet been received.

Dr. Hill's Visit.—At a meeting of the Standing Committee on the 1st December the President reported that Dr. Hill, Director of the Kew Gardens was to visit New Zealand in January. It was resolved that the President should ascertain the conditions under which Dr. Hill is visiting New Zealand and take action on behalf of the Institute.

Standing Committee Report.—The foregoing report was considered clause by clause. In the paragraph relating to Societies' celebrations it was agreed to insert the words "Auckland Institute" before "Wellington Philosophical Society."

The report as amended was adopted.

BUSINESS ARISING FROM REPORT OF STANDING COMMITTEE.

1. Government Printer's Charges.—The Hon. Treasurer referred to the correspondence which had been exchanged between the Hon. Minister of the Printing Office and the New Zealand Institute, and reported that no further action could be taken.—Received.

2. Levy on Volume 58.—On the motion of Mr. Hudson seconded by Professor Park it was resolved that the levy be 5/- per volume as previously.

3. Reference List of Periodicals.—On the motion of the Hon. G. M. Thomson seconded by Professor Easterfield it was resolved that a hearty vote of thanks be conveyed to Mr. Archey for his work in connection with the compiling of the Reference List of Scientific Periodicals.

4. Manawatu Philosophical Society.—Mr. Eliott reported that the Manawatu Philosophical Society would shortly be reorganized and at present an endeavour was being made to find a suitable secretary.

HONORARY TREASURER'S REPORT FOR THE YEAR ENDING 31st DECEMBER, 1927.

The Balance Sheet for the year ending 31st December, 1927, shows a Debit Balance of £608/0/7, as compared with a Debit Balance of £163/19/- for the same period in 1926.

The cost of Volume 57 was considerably greater than anticipated owing to its size (1220 pages), and to the very large number of corrections in author's proofs, extra for special setting, process and line blocks, etc. The contract price was £1,016/13/4, but the above-mentioned extras brought the total cost up to £1,365/11/-. However, even this amount was £245 below the Government Printer's account for Volume 56 (860 pages), but at the same time the cost of Volume 58 and succeeding Volumes is of urgency and importance. The Standing Committee should take the necessary steps to limit the size to reasonable dimensions, and prevent a recurrence of unnecessary extras, particularly the cost of author's corrections. If we are to carry out our undertaking to pay off the balance due to the Government Printer, £1,237/18/6, then the cost of the *Transactions* should not exceed £850 per annum. It can be done for this, and the responsibility is with the Standing Committee to act accordingly.

The Trust Accounts continue to show a satisfactory condition. The Carter Bequest Capital has increased by £402 during the year. Five per cent. Post Office Inscribed Stock for £400 purchased in 1922 for £388/8/4 matured in November last, and has been reinvested in 5½ per cent. Post Office Inscribed Stock maturing in 1933, together with a further £200 available in the Carter Bequest.

The proposal to alter the date of the Annual Meeting is a good one. The present time of closing the books and accounts for the year, viz., 31st December, is a most awkward one for the Secretary, Auditor and Hon. Treasurer. The 31st March, which would coincide with the Government year, would be a much more convenient date.

The Books and Accounts have, as usual, been accurately kept by the Assistant Secretary.

(Signed) M. A. ELIOTT,
Hon. Treasurer.

NEW ZEALAND INSTITUTE.—STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE YEAR ENDING 31ST DECEMBER, 1927.

Receipts.

	£	s.	d.
Balance as at 31st December, 1926	2,112	4	10
Statutory Grant	1,500	0	0
Levy Volume 57	221	10	0
Authors' Reprints	19	17	2
Publications Sold	59	4	6
Reference Lists Sold	17	16	8
Authors' Corrections paid	34	13	4
Contributions to Publication Expenses	52	0	0
Wellington Phil. Soc., Half Share Carter Beq Legal Expenses	19	8	6
Interest, Post Office Savings Bank	52	18	3
Research Grants from Treasury	746	13	6
Carter Bequest—Interest	382	5	0
Hector Memorial Fund—Interest	68	10	0
Hutton Memorial Fund Interest	69	0	0
Carter Library Legacy -Interest	8	0	0
Endowment Fund -Interest	20	10	0
Carter Bequest, P O.S.B. A/c Transfer to B.N.Z.	65	1	2
Hector Memorial Fund, P O.S.B. A/c Transfer to B.N.Z.	10	15	0
	£5,460	7	11

Expenditure.

	£	s.	d.
Ferguson and Osborn, Ltd.	1,666	17	6
Government Printer	400	0	0
Whitcombe and Tombs, Ltd.	3	10	6
Salary	300	0	0
Travelling Expenses	51	1	4
Charges (Insurance, Bank Com., etc.)	8	7	2
Petty Cash (Postages, etc.)	14	10	5
Research Grant Instalments	634	15	7
Bell, Gully, Mackenzie and O'Leary—Carter Beq- Legal Exs.	38	17	0
Hector Award (Dr. Cotton)	45	0	0
Hutton Research Grant Instalment	10	0	0
Carter Bequest—Interest Invested	401	16	2
Trust Funds Transferred to Accounts	139	11	8
Balance as under	1,746	0	7
	£5,460	7	11

	£	s.	d.	£	s.	d.
Balance in Bank of New Zealand	1,123	1	3			
Less Unpresented Cheques	564	9	8			
				558	11	7
Balance in Post Office Savings Bank				1,173	18	11
Petty Cash in Hand				13	10	1
				£1,746	0	7

NEW ZEALAND INSTITUTE REVENUE ACCOUNT FOR YEAR ENDING 31ST DECEMBER, 1927.

Expenditure.

	£	s.	d.
Balance at 1st January, 1927	163	19	0
Printing, etc.	2,006	7	6
Salary	300	0	0
Travelling Expenses	51	1	4
Postages, etc.	14	10	5
Insurance	3	12	11
Wreath	2	2	0
Bank Charges	1	10	0
Sundries (Cartage, freight)	1	2	3
Accounts Written Off:—			
Author's Corrections	17	10	11
Reprints	0	18	2
	£2,562	14	6

Income.

	£	s.	d.
Government Grant	1,500	0	0
Contributions	52	0	0
Levy and Sales of Publications	402	13	11
Balance, 31st December, 1927	608	0	7
	£2,562	14	6

To Balance	£608	0	7

New Zealand Institute.—Statement of Assets and Liabilities as at 31st December, 1927.

Liabilities.

	£	s.	d.
Carter Bequest Capital Account	6,806	8	8
Hector Memorial Fund Capital Account	1,184	18	1
Hutton Memorial Fund Capital Account	1,114	5	10
Endowment Fund Capital Account	397	17	0
Hamilton Memorial Fund Capital Account	48	7	11
Carter Legacy Capital Account	100	0	0
Carter Bequest Revenue Account	18	3	2
Hector Memorial Fund Revenue Account	44	18	7
Hutton Memorial Fund Revenue Account	67	1	5
Endowment Fund Revenue Account	139	18	11
Hamilton Memorial Fund Revenue Account	6	13	9
Carter Library Legacy Revenue Fund	17	6	11
Ferguson and Osborn, Ltd.	243	10	9
Government Printer	1,237	18	6
Library Fund	176	19	4
Research Grants	667	5	0
	£12,271	13	10

Assets.

	£	s.	d.	£	s.	d.
Inscribed Stock				7,568	2	11
Post Office Inscribed Stock				2,035	6	8
Cash in Bank N.Z.	1,123	1	3			
Less Unpresented Cheques	564	9	8			
				558	11	7
Cash in P.O.S.B.				1,173	18	11
Petty Cash in Hand				13	10	1
Outstanding Accounts				111	11	4
Carter Bequest P.O.S.B. Account				18	3	2
Hector Memorial Fund P.O.S.B. Account				44	18	7
Hutton Memorial Fund P.O.S.B. Account				67	1	5
Hamilton Memorial Fund P.O.S.B. Account				55	1	8
Carter Legacy P.O.S.B. Account				17	6	11
Balance of Liabilities over Assets				608	0	7
				£12,271	13	10

	£	s.	d.
To Balance	£608	0	7

New Zealand Institute.—Trust Accounts.

Carter Bequest Revenue Account for the Year Ending 31st December, 1927.

Dr.	£	s.	d.	*Cr.*	£	s.	d.
To Interest re-invested	401	16	2	To Balance 31/1/26	56	1	11
Legal Exs., Bell, Gully, Mackenzie & O'Leary	38	17	0	Interest	383	5	11
Balance	18	3	2	Half Share from Wellington Phil. Soc.	19	8	6
	£458	16	4		£458	16	4
				By Balance	£18	3	2

Hector Memorial Fund Revenue Account for the Year Ending 31st December, 1927

Dr.	£	s.	d.	*Cr.*	£	s.	d.
To Prize (Dr. Cotton)	45	0	0	By Balance	20	10	4
Balance	44	18	7	Interest	69	8	3
	£89	18	7		£89	18	7
				By Balance	£44	18	7

Hutton Memorial Fund Revenue Account for the Year Ending 31st December, 1927.

Dr.	£	s.	d.	*Cr.*	£	s.	d.
To Part Grant (Miss Mestayer)	10	0	0	By Balance	6	12	9
Balance	67	1	5	Interest	70	8	8
	£77	1	5		£77	1	5
				By Balance	£67	1	5

Hamilton Memorial Fund Revenue Account for the year Ending 31st December, 1927.

Dr.	*Cr.*	£	s.	d.
	By Balance	4	11	7
	Interest	2	2	2
		£6	13	9
	By Balance	£6	13	9

Carter Library Legacy Revenue Account for the Year Ending 31st December, 1927.

Dr.	*Cr.*	£	s.	d.
	By Balance	9	3	6
	Interest	8	3	5
		£17	6	11
	By Balance	£17	6	11

Examined and found Correct.
G. F. C. CAMPBELL,
Controller and Auditor-General.

Financial Statements.—The Hon. Treasurer moved the adoption of his slightly amended report and the Statements of Receipts and Expenditure, Revenue Account, Liabilities and Assets, and Trust Accounts. Seconded by Professor Park and carried.

REPORT OF THE PUBLICATION COMMITTEE.

The Committee is in the happy position of being able to report not only the issue of Volume 57, which was issued on 10th March, 1927, but also the issue of the first three quarterly numbers of Volume 58, Parts 1 and 2 as a double number on 15th August, 1927, and Part 3 on 15th November, 1927. Part 4 (December) will be out in February.

For Volume 57 sixty papers by forty authors were submitted, of which forty-seven papers by thirty-five authors were published. Owing to two or three exceptionally long papers, this volume turned out the biggest yet issued by the Institute, consisting of 10 plus 1,123 pages, of which 143 were Proceedings and Appendix, and Minutes and Proceedings of the Third Science Congress of the New Zealand Institute (15 pages), with eighty plates and the usual proportion of line drawings.

In Volume 58, sixty papers by forty-five authors were submitted, of which fifty-one papers by thirty-seven authors have been, or are being, published. Parts 1 and 2 (March and June) contain 4 plus 188 pages, of which thirty-four are the Minutes of the Annual Meeting of 27th January, 1927. It also contains the Presidential Address of Mr. B. C. Aston for the year, seventeen papers by fifteen authors, two reviews and an obituary notice, and includes twenty plates Part 3 (September) contains 4 plus 169 pages, the whole of which are eighteen papers by fourteen authors, with seventeen plates and an extra proportion of line drawings. Details for part 4 (December) cannot be given, as it is still in the printer's hands, but it will not contain more than 250 pages, and will include probably eleven papers by ten authors, besides the Appendix and Index.

An attempt has been made to include reviews: Mr. Aston has reviewed work on the Correlation of Iron Starvation in Ruminants with the Physical Features of the Country, and Mr. Millar has reviewed Dr. R. J Tillyard's book, "The Insects of Australia and New Zealand" It is felt that the Institute should take some notice of important books or work in this way.

Attention may be drawn to two important facts. Firstly, there was not a paper on hand when the December number of the *Transactions* went to press, everything was so up-to-date that papers read less than two months before are included in that number This means, too, that in future contributors may see their papers in print at any rate within three months of their being read, most probably within two months. This is partly due to the promptness of the printer, and the reliability that can be placed on his promise to have a part out by a certain date. Secondly, the financial position of the Institute as regards the *Transactions* will in future be in a most satisfactory state; the constable will not be overrun as he has been, unavoidably under the conditions, in the past. This again is largely due to the reasonable charges of the printer. We would take this opportunity of stressing the fact that the printer has striven his utmost, at times at financial loss to himself, to turn out work in as creditable a manner as possible. It must be remembered that the first volume he undertook, Volume 57, was the largest the Institute has had, and the work was of a technical nature of a kind this printer was not accustomed to, whereas the former printer had had years' of experience in it; and as we who deal with our present printer know the trouble he takes to turn out our work as we wish it, we trust the consideration shown for us by him may be shown by the Institute for him.

During the year was issued Part 4 of Dixon's Bryology of New Zealand; this leaves a final part to complete this Bulletin, and Mr. Dixon has written to say this part is in hand. The Reference List of Periodicals prepared by Mr. Gilbert Archey, was also printed, the proofs being read by Miss Wood, Assistant Secretary. A four-page advertisement of publications on sale by the Institute was also printed and the bulk sent to Messrs. Wheldon and

Wesley, Ltd., who undertook to distribute it, with their own circulars, among their customers. The printing of these three items was also done by the printers of the *Transactions*, Messrs. Ferguson and Osborn, Ltd.

(Signed) JOHANNES C. ANDERSEN,
For the Publications Committee.

Publication Committee's Report.—Mr. Hill suggested that members who wished to receive the *Transactions* in a single volume instead of in four parts be provided for. On the motion of the President this was referred to the Standing Committee. The report was adopted.

REPORT OF THE GREAT BARRIER REEF COMMITTEE.

Five meetings of the Committee were held during the past year.

A British Barrier Reef Committee has been formed in England to co-operate with the Australian Committee.

British Expedition.—The Australian Committee agreed to find as its maximum obligation £1,000 to aid the expedition, which is to be postponed until 1928 in favour of a larger scheme. The expedition will examine a section of the Great Barrier Reef off Cairns from the shore to the open ocean. The party will work for twelve continuous months. The main problems to be investigated include the physiology of the coral polyps, method of calcium deposition, distribution of plankton, and properties of sea water.

FINANCIAL STATEMENT AT 1ST SEPTEMBER, 1927.

	£ s. d.
Gross Receipts	5,692 9 2
Expenditure	4,631 17 4
Balance in Hand	£1,060 11 10

(Signed) W. R. B. OLIVER,
N.Z. Institute Representative on the Committee.

On the motion of the President the above report was adopted.

REPORT OF THE INSTITUTE'S REPRESENTATIVE ON THE TONGARIRO NATIONAL PARK BOARD.

I have to report that during the past year one meeting of the full Board was held at Wellington on 17th June, and three meetings of the Central Executive Committee consisting of the Wellington members were held on January 12th, May 12th, and December 8th, all of which were attended by me. The Chairman and Secretary make it a point to consult members before fixing a date for any meeting, a fair and business-like proceeding which ensures a maximum attendance. It might well be copied by some other Institutions.

Heather.—The committee appointed to report on the imported heather question has begun work, and although at first handicapped by the absence in England of Mr. E. Phillips Turner, has presented a preliminary report. The Annual Report of the Board, which was presented to Parliament and which is before you, states that, "Much of the criticism which has been "levelled in this connection is based on an imperfect knowledge of the true "position, and can serve no other purpose than to convey a false impression "that the whole area of the Park is a blazing mass of heather, choking out "all native life. This, as will be seen by the report of the sub-committee, "is contrary to fact."

I am not aware that any responsible person has made statements that could tend to convey such an impression, but what is earnestly sought by all interested in preserving the Park in its present condition is, that the whole area or any part of the Park *shall not become* "a blazing mass of heather," or that any great portion of the flora may be choked out. If

action should be delayed until such a state of affairs is reached, it will then be too late to apply an effective remedy, and the Tongariro National Park will cease to be representative of New Zealand. No conclusions were drawn by the Heather Committee in framing the report, and cannot justly be drawn by others.

Road Making.—A much more serious menace than the choking of the native vegetation by heather is the proposal to sacrifice a two chain width of forest at Ohakune as a preliminary to the construction of a motor road from Ohakune up the Mountain. It was suggested that the sale of timber from such a strip would aid in making the road. Such a width of road would necessitate perpetual vigilance to keep the second growth down, and if not kept clear the view of the forest would be obscured. A committee of the Board visited the site in winter, and found the track knee deep in mud in places, which is good argument for improving the track, but not for making a road. The Annual Report of the Board states that £161/12/- was expended on the Ohakune Track. The work consisted in straightening and shortening the route. This entailed much cutting, clearing and formation, and the erection of several small bridges, and laying down 30 chains of corduroying.

The Institute's Standing Committee passed the following resolution:—"That the New Zealand Institute opposes any suggestion for widening the track from Ohakune to the Ohakune Hut, but suggests that the track from Ohakune Junction through the Podocarp forest be improved without sacrificing any of the timber trees."

I am of opinion that this Institute should pass a very strong resolution with the view of awakening public opinion to demand that no more timber trees may be sacrificed than is absolutely necessary in making tracks, and I consider that no timber trees should be felled unless certified to as necessary by a competent committee which should be appointed. The whole matter of the proposed road has been referred to a meeting of the full Board to be held at the Park early in the New Year.

It is satisfactory to report that matters are satisfactorily advancing towards the erection of an adequate Hostel for the accommodation of visitors to the Park, and that the Bruce Trustees, with characteristic generosity, have made a donation of £500 towards the erection, which will carry a Government subsidy of a like amount.

(Signed) B. C. Aston

On the motion of the President the above report was adopted.

Representative on Park Board.—On the motion of Professor Park seconded by Professor Worley it was resolved that Mr. B. C. Aston be elected as representative of the Institute on the Park Board.

REPORT OF THE INSTITUTE'S REPRESENTATIVE ON THE NEW ZEALAND INSTITUTE OF HORTICULTURE.

This Institute is continuing the work mentioned in my last report. The passage of an Act of Parliament last Session giving among other things to the Institute power to grant diplomas should strengthen its position as the New Zealand authority on Horticultural matters.

An interesting Bulletin, of which Mr. Gilbert Archey is the Editor, is published dealing with horticultural matters.

I brought the matter of Dr. A. W. Hill's projected visit to New Zealand before the Committee at the July meeting. The matter was at once taken up enthusiastically, and suitable receptions have been arranged. It is to be hoped that Dr. Hill, as a representative of the British Man of Science, will have time to meet members of the Board of the New Zealand Institute at the Annual Meeting.

Meetings of the Sub-committee to consider the establishment of a National Botanical Garden were attended by me and a report prepared. It is to be hoped that details of the progress made with the Wilton's Bush scheme will show that efforts are being made to carry out the high ideals expressed at the opening last year.

The frequency of the meetings of the Horticultural Institute renders it impossible to attend all of them; a proposal to hold some of the meetings in the evening may do much to allow those who are busy at their own work in the day time to attend.

The "Banks Lecture" has now become an annual feature of the Horticultural Institute, the subject of the last one most appropriately being "On the Fertility of the Soil," by Mr. L. J. Wild, of Feilding.

In addition to the subjects mentioned in my last report this Institute has taken up the following:—

(1) Awarding Cups for competition in Horticulture.
(2) Plant Registration.
(3) Judging Rules at Shows.
(4) Judges' Register.
(5) Popular Lectures in connection with the W.E.A.
(6) Native Plant Preservation.

The Institute has now two paid officers, a Dominion Organiser and a Dominion Secretary.

Attempts to secure grants from the Department of Scientific and Industrial Research in Horticulture are being made.

(Signed) B. C. Aston.

The above report, on the motion of the President, was adopted.

HONORARY LIBRARIAN'S REPORT.

Nothing of importance has to be reported regarding the Library A few new exchanges have been entered into, and a careful watch is kept upon the regularity of the Journals received.

It is satisfactory to note the publication of the Institute's Reference List of Scientific Periodicals, compiled by Mr Archey. This will do much to increase the accessibility and usefulness of the Library.

The binding of periodicals has been proceeding, but much yet remains to be done, and there are still, unfortunately, many sets which will have to be completed by the filling up of gaps.

(Signed) D. M. Y. Sommerville

The above report was adopted.

REPORT OF THE RESEARCH GRANT COMMITTEE.

Ten applications for research grants were made during the year. The Committee recommended grants in eight cases, to the total amount of £813, in one case it suggested that the proposed research might appropriately be carried out by the Public Works Department, and, in the remaining case, the Committee was unable to make a recommendation.

Reports or interim reports have been received from most of those holding grants and abstracts of these, kindly prepared by the Assistant Secretary, are appended. In a few cases no report has been sent in.

The reports and abstracts were received on January 12th and 13th. Owing to the short time available, and to the absence from Christchurch of the majority of the Committee, it has not been possible to discuss fully all the points raised, and to present a detailed report on the accounts given of the researches conducted. Some general questions arise, and the following matters, in particular, are submitted for review by the incoming committee:—

1. Detailed vouchers of the expenditure are supplied only in a few cases.
2. Certain grantees have suggested that the unexpended balance of their grants should be transferred to other purposes or persons, or have made recommendations as to the custody of apparatus purchased.
3. The question of cancelling grants where no work has been done within a reasonable time.

(Signed) Chas. Chilton.
Chairman Research Grants Committee.

RESEARCH GRANTS REPORT FOR THE YEAR ENDING 31st DECEMBER, 1927.

Dr. C. E. Adams was, in 1925, granted £200 for research on Southern Stars. He reports, that through the assistance of the Public Works Department, he has been supplied with a design of an interferometer to be fitted to the 9-inch City Telescope at Kelburn. The Public Works Department has gone into the matter very carefully, and advises that the work be placed in the hands of an English firm, such as Cooke, Troughton and Simms. The Mt. Wilson Observatory has supplied the four plane mirrors for use on the interferometer. No portion of the grant has yet been expended, and Dr. Adams asks that he may obtain quotations for the construction of the interferometer.

Dr. H. H. Allan was, in 1924, granted £50 for research on Mt. Egmont forests. He reports that it has not been possible to conduct any further field work since his last report. The research will be completed in May, 1928. Advantage was taken of the presence of Dr. G. E. du Rietz, of Uppsala University, to discuss various problems, especially those connected with the significance of the lichen flora and vegetation and a representative set of lichens was determined by Dr. du Rietz. Mr. Dixon, of Northampton, has also assisted with the treatment of mosses. No expenditure has been incurred during the year, and grantee has a balance in hand of £23/0/10.

Dr. H. H. Allan was, in 1923, granted £30 for research on cocksfoot and ryegrass. He reports that, owing to flooding of the area devoted to ryegrass, much of the work has to be repeated. Investigations have been continued on the phenomena of germination and life-histories of the species. Several selections of promising individual plants have been made, and these have been multiplied by clonal divisons. Comparisons of strains of different origins have been continued, and it has been determined that New Zealand grown material affords the best means of furthering the objects of research. Advantage was taken of the visit of Mr G Stapledon, of the Aberystwyth Plant Breeding Station to discuss the problems arising, and methods of investigation for dealing with them. No expenditure was incurred and grantee has in hand £20/16/6.

Mr. G. Archey was, in 1926, granted £40 for research on Chilopoda. He reports that general collecting of all orders of Chilopoda has been carried out in the Auckland district, and a small portion of the grant expended on this. A detailed study of the Geophilomorpha has been practically completed and a revision of the New Zealand species of the order can be presented as soon as certain specimens sent to Europe and the United States for comparison with types have been returned. Expenditure to date has been £32/18/11.

Professor W. N. Benson was, in 1925, granted £50 for preparing rock-sections of Dunedin region. He reports that the work of the detailed mapping and petrological examination of the volcanic rocks of the Dunedin district has been continued by him and his students. One of the latter has made a detailed map of Waitati Valley, finding therein a series of complexly faulted lavas. Further work will be continued during the coming vacation. Expenditure to date is £22/15/-.

Dr. C. Chilton was, in 1925, granted £100 for research in food-supply of New Zealand Fishes. He reports that further progress has been made by his assistant, Mr. E. W. Bennett, in the collection and study of Entomostraca. One paper has been written, and several others are in course of preparation. Some collection of fresh and brackish water Entomostraca have been made, and some of these have been sent to Dr. V. Brehm, of Bohemia, for examination and identification. He has discovered among them a number of new species of Ostrocoda and Copepoda. Reports on the first part of his researches are expected soon for publication in the *Transactions* of the New Zealand Institute. Dr. Brehm has also sent collections of Cyclopidae and Hydracarina from the same material to other scientists in Europe. The total expenditure to date is £55/0/3, and, as Dr. Chilton and Mr. Bennett are leaving Christchurch for Nelson, he sees little prospect of continuing the research, and he refunds a balance of £4/19/9.

Mr. W. C. Davies was, in 1921, granted £50 for research on soil bacteria and protozoa. He reports that the investigations of the previous year concerning the correlation of bacterial counts with the relative fertility of Nelson soils have been continued as far as the exigencies of other work have permitted. Several fresh soils, including those of the Nelson Haven and Mud Flats, and the Pakihi lands of the West Coast, are still under consideration and publication of the results is being delayed to permit the inclusion of these in the series. The whole of the grant has been expended.

Mr. H. G. Denham was, in 1925, granted £115 for research on Low Temperature Carbonisation of New Zealand Brown Coals. He sent a table of the results of the analyses of the coals obtained to date by his assistant. The methods adopted are outlined in a publication of the English Fuel Research Board, "Physical and Chemical Survey of the National Coal Resources, No 7" Gas analysis was conducted with the Hempel apparatus, hydrogen absorbed over copper oxide, and the remainder exploded for methane and ethane. The whole of the grant has been expended, and the work is being continued by the Fuel Committee of the Department of Scientific and Industrial Research.

Professor Easterfield was, in 1921, granted £200, and in 1926 an additional £100 for research on the cool storage of fruit. He reports that the results of the 1926-27 experiments have been published during the year in the form of a pamphlet Experiments are now being extended in the direction of using other varieties of fruit and still further modifyng the conditions under which the fruit is stored. The general result of the researches has been a great increase of knowledge on the conditions under which apples can safely be stored for comparatively long periods. The whole of the grant has been expended.

Dr. C. C Farr was, in 1924, granted £250 for research on Helium in New Zealand He reports that he and Mr. Rogers have continued the investigation during the whole year, and gases have been collected from the Northern part of the South Island, and from the Taranaki, Hawke's Bay, and Gisborne districts, and their Helium content has been determined. As Mr. Rogers has been able to devote his whole time to this investigation progress has been much more rapid, and it is hoped to complete the work during the coming year. Specimens of all gases collected have been preserved for chemical analysis, and the results, together with the Helium results, will be published, and it is hoped to possess an accurate knowledge not only of Helium content but also of the general character of the gas effusions which are to be found in so many different parts of the Dominion. The expenditure to date is £161/1/8.

Dr. C. C Farr was, in 1921, granted £15 for research on the physical properties of gas free sulphur. He reports that work in connection with the research has gone on as opportunity presented itself, and this year it has been brought to the publication stage, and an account of the work done and the results arrived at has been prepared in the form of a paper by Farr and McLeod, and has been sent to England for publication. Owing to the experimental difficulties involved and also to lack of time, the investigation has been rather prolonged, but it is hoped that the results are of sufficient importance to justify the labour which has been put into it. There has been no expenditure during the year, the unexpended balance being £4/18/1.

Dr. C C. Farr was, in 1923, granted £30 for research on the relationship between radium emanation and goitre He reports that as far as the work contemplated originally is concerned it was finished with the publication of a paper by Mr. M. N. Rogers, giving the results of an examination of different sources of water supply in Canterbury and elsewhere. At this stage, however, the work was continued by Dr. Milligan in conjunction with Mr. Rogers, and papers have been read by them during the year embodying the results of injecting rabbits with radon, and of impregnating water inhabited by trout with radium emanation. The work is more properly carried out with the aid of a Bio-chemist, and it is suggested that the balance of the vote should be handed over to Mr. Rogers and Dr. Milligan, so that experiments may be continued by them. No expenditure was incurred during the year, the unexpended balance being £14/0/7.

Mr. H. J. Finlay was, in 1924, granted £100 for research on tertiary mollusca. He reports that the work is covered by papers which have been published in the *Transactions* of the New Zealand Institute. Perhaps the main work done has been the critical review of New Zealand recent and tertiary mollusca, the results of which are embodied in "Further Commentary in New Zealand Molluscan Systematics." Some hundreds of species have been described and thousands identified, many new genera have been proposed, and a valuable reference collection built up for the use of students of New Zealand Mollusca. The whole of the grant has been expended.

Mr. F. W. Foster was, in 1923, granted £25 to collate the notes, MSS., etc., of the late Sir David Hutchins. He reports that he is still working on the notes and the MSS., and he hopes to submit a large portion of the work early in the New Year. No expenditure has been entailed.

Dr. F. W. Hilgendorf was, in 1926, granted £50 for a calculating machine. This instrument is used for the purpose of co-ordinating agricultural experiments and is assisting investigations in many directions, and is in almost daily use. It has been used in correlating scattered manurial experiments in various places, and the first Bulletin on this subject is now in the press. The whole of the grant was expended in the purchase of the machine.

Mr. H. Hill was, in 1925, granted £50 for completing a survey of the Taupo Plains. He forwards a report of the results of his investigations which have covered a wide area of land, and have dealt with many aspects of the survey as follows: Sulphur deposits, clays, etc., water finding, rhyolite deposits, exploitation and value of the pumice lands, etc. There is an unexpended balance of £8.

Dr. J. H. K. Inglis was, from 1923 to 1926, granted amounts totalling £75 for research on the essential oils of native plants. He reports that during the year work has been begun upon the oils of several plants, but no research has been carried through to completion. A considerable amount of oil has been obtained from White Pine and Totara, and work on these will be carried on next year. Work has also been carried on on Silver Pine, some varieties of Rata, Black Pine and Red Pine. There is an unexpended balance of £2/14/10.

Mr. G. Jobberns was, in 1926, granted £50 for correlation of shore platforms of the North East Coast of the South Island. He reports that the work is now well in hand and a complete preliminary survey of the coast has been made from Blenheim to Banks Peninsula. As many problems have arisen in the course of the work most of the coast will have to be revisited. This he proposes to do in the vacation. To complete the work, terraces of East Coast rivers will have to be examined. This is likely to take a considerable time, and grantee has applied for an additional amount. The whole of the present grant has been expended.

Mr. F. V. Knapp was, in 1925, granted £25 for procuring Maori Artifacts, etc. He reports that no further research has been carried on during the year, but he hopes to visit a rock shelter beyond Lake Rotoroa used by Maoris in their journeys from the East to the West Coast, and also to visit several camping sites in the Golden Bay district. No further expenditure has been incurred. Balance remains, £16/16/0.

Mr. R. M. Laing was, in 1924, granted £100 for research on New Zealand Algae. He reports that he published a paper on the "External Distribution of the New Zealand Algae and Notes on Some Algological Problems," and another paper on the genus Porphyra is also completed. He considers this the most important (economically) of the genera of algae; the species are largely used for food in Great Britain, Japan, Hawaii, California and elsewhere. In Japan they are extensively cultivated. He hopes to continue the work next year. The expenditure to date has been £65/7/11.

Dr. J. Malcolm was, in 1919-1926, granted a total amount of £631/3/7 for research on the the food-values of New Zealand fishes. He reports that he has personally carried out analyses of monthly samples of Stewart Island oysters for the ordinary constituents, and for their content of Vitamin A.

At present the work is incomplete, and he hopes to publish the results during the year Samples of tinned toheroa were also examined and found to be rich in Vitamin A. A paper on this subject is being prepared for publication. As it is unlikely that Dr. Malcolm will be able to continue the work on fishes after completing what he has in hand, he wishes to thank the Institute for the financial help he has received without which the work could not have been done. The expenditure to date is £609/18/-.

Dr. J. Malcolm was, in 1918, granted £30 for research into the Pharmacology of New Zealand Plants. He reports that no further work has been possible this year, and he suggests that the unexpended portion, £10, be used for isolating a quantity of Pukateine, sufficient to carry out research into its possible therapeutic uses. He suggests that Mr. Aston might undertake to do this.

Dr. Marsden was granted, in 1924, £60 for seismological research. He reports that neither he nor Dr. Adams has been able to undertake the work and no expenditure has been incurred

Mosquito Control Committee was, in 1925, granted £100 to carry on an investigation in Auckland. A lengthy report of the work done was submitted to the Research Grants Committee of the New Zealand Institute earlier in the year, and this Committee reported it as satisfactory. The work, however, is in a preliminary state, and the Mosquito Control Committee applied for an additional grant in order that the work might be continued uninterruptedly, and it proposes (in the event of the application being approved) to have a man giving his whole time to the research. The whole of the £100 has been expended.

Mr. A. W B Powell was, in 1925, granted £50 for a survey of the molluscan fauna of Manakau Harbour. He reports that data is steadily being accumulated, but owing to the difficulty of access to the greater part of the shore line, the work is not likely to be completed for a year or two. In the meantime, other work is being accomplished with the aid of the microscope previously purchased by means of the grant. Several lengthy papers are almost ready for publication. Expenditure to date is £37/13/7.

Research Committee for Ecological Survey of the Waitemata Harbour was, in 1925, granted £65 for this work. It reports the next report will include the final results of the investigations. During the past year several expeditions were made, and collecting stations established at all important points Observations and data have been made on mammals and birds, fish, invertebrate animals and plankton and seaweeds. Expenditure during the year amounted to £13/4/1.

Mr. W. F. Short was, in 1925-26, granted £175 for an investigation into the constituents of New Zealand Essential Oils. He reports that the catalytic hydrogenation apparatus arrived broken, and it was necessary to wait for replacements from the makers in Europe. The apparatus, however, is now in working order. He has been working on *Sesquiterpene* and *Leptospermol*, and is making preparation for an attack on the constitution of other constituents of essential oils from plants growing in New Zealand. The total expenditure to date is £169/15/8.

Mr. H F Skey, who took over from Capt. Isitt a balance of £36/10/9, and who was granted an additional £175 at the end of last year, for research on Upper Air, reports that since last report 103 balloon flights have been observed. An account of the results for the first 87 flights was given before the Canterbury Philosophical Institute in August last, the results being illustrated in graphic form. The apparatus purchased by means of the grant was loaned to the Department of Scientific and Industrial Research during February and March of this year, and intensive series of observations were made, and the results are to be published in the Annual Report of the Christchurch Magnetic Observatory, and Mr. Skey requests that permission be given to him to have all the observations he makes published in the report, also so that all the results should be available together. The additional improved aero-theodolite ordered from Messrs. Watts and Son should shortly be delivered, and the balance of the grant, £170/1/7, should be sufficient to meet this expense and to carry on during 1928.

Professor R. Speight was, in 1919, granted £225 for geological survey of the Malvern Hills. He reports that the final report, covering the whole work of the research is being published by the Department of Scientific and Industrial Research. There is a small balance in hand of £1/1/3, which if not required will be refunded.

Dr. J. A. Thomson was, in 1919, granted £100 for research into the chemical character of igneous rocks. He reports that owing to ill-health he had to suspend work on this research. There is an unexpended balance of £15/12/6.

Mr. A. Tonnoir was, in 1925, granted £50 for research on New Zealand glow worms. He reports that, owing to his removal from Christchurch, where the research was instituted, to Nelson, he has been unable to continue. He hopes that next year he may be able to resume. He has a balance in hand of £7/0/3.

Messrs. Wild and Tankersley were, in 1923, granted £25 for a soil survey of the Manawatu District. Mr. Wild reports that the work has progressed as limited opportunities permitted. He does not anticipate requiring the unexpended balance of £18/5/6.

Professor F. P. Worley was, in 1923, granted £25 and in 1925 an additional £25 for research on the chemistry of essential oils and other products of the New Zealand flora. He reports that during the year the essential oil of Mairehau (*Phebalium nudum*) has been investigated, and the results are being prepared for publication. During the summer he intends collecting a supply of leaves of *Melicope ternata* for investigation next year. Expenditure to date is £21/8/6.

Mr. F. H. McDowall was, in 1924, granted £60, and in 1926 an additional £20, for an investigation of Ngaio Oil. He reports that the results have been published in the Journal of the Chemical Society under the title "Constituents of *Myoporum Lactum*, Forst. (The Ngaio), Parts 1 and 2" Part " deals with Hydrogenation of Ngaione and Ngaiol and Dehydration of Ngaiol, and was published early in the year. Mr. McDowall is working on this research at London University, and his grant is being administered through the High Commissioner who has £20 in hand.

Reports have not been received from the following:—

Mr. G. Brittin, £100, Fruit Tree Diseases.

Mr. G. Salt, who took over Professor Burbidge's research grant of £125 for Long Wave Wireless from Europe.

Mr. H. Hamilton, £30, Cave Fauna of New Zealand.

Mr. E. K. Lomas, £25, research on Intelligence of School Children.

Mr. W. J. Phillipps, £30, Life History of New Zealand Fishes.

Research Grant Committee Report.—On the motion of the Chairman of the Research Grant Committee, Dr. Chilton, the report was adopted.

Research Property.—Certain questions in regard to the disposal of books and apparatus were referred to the Standing Committee.

Date and Place of Annual Meeting.—On the motion of the Hon. G. M. Thomson, it was resolved that the next Annual Meeting be held *pro forma* in Wellington on the 10th January, 1929, and adjourned to Auckland at a date to be fixed later.

Science Congress, 1929.- It was resolved that the next Science Congress be held in Auckland at a date to be fixed.

National Research Council.—On the motion of Professor Farr seconded by Mr. A. M. Wright it was resolved that the constitution under the New Zealand Institute of the National Research Council

be referred to the Standing Committee to consider and report at next Annual Meeting and that in the meantime the Board of Governors act as the National Research Council.

Pan Pacific Science Congress.—Correspondence from the President and General Secretary of the Fourth Pacific Science Congress, to be held at Java in May, 1929, was read, and copies of the First Announcement laid on the table. It was resolved that incorporated societies be circulated in regard to the matter.

Cape Kidnappers Bird Sanctuary.—A report from the Secretary of the Board was received.

Hutton Research Grants.—An application was received from Dr. Chas. Chilton for a grant of £50, for expenses in connection with his researches on New Zealand and Antarctic Crustacea and one from Mr. H. J. Finlay for £10, for defraying photographic expenses in connection with his research on New Zealand mollusca. Both applications on the motion of Hon. G. M. Thomson seconded by Professor Worley were granted.

Hutton Award.—A letter from Dr. Benham was referred to the Hutton Award Committee for consideration. Dr. Chilton was added to the Committee.

Storage of Specimens.—A letter from the Turanganui Public Library in regard to storing specimens was referred to the Standing Committee.

Waipoua Forest.—On the motion of the Hon. G. M. Tromson seconded by Dr. Chilton it was resolved: "That this Institute views with regret the action of the Government in opening a public road through the Waipoua Forest, when one which would have served the needs of the district and of the settlers in the neighbourhood could have been constructed round the forest area at the same or only a slightly increased cost." It was further resolved: "That as the Waipoua Forest contains the only large tract of Kauri forest left in New Zealand, it is desirable that it should be preserved for all time and that no trees should be removed from the area except under the authority of and by the officers of the Forestry Department, and only where it is considered that such removal of trees is essential for the regeneration of the Kauri forest." Dr. Thomson moved and Professor Easterfield seconded and it was carried: "That the Auckland Institute be asked to set up a Vigilance Committee to preserve the Waipoua and Trownson forests intact."

Annual Meeting.—Mr. Hill moved and Dr. Cockayne seconded: That a meeting of the New Zealand Institute be held in Wellington on the 10th January, 1929, and adjourned to the Tongariro National Park two days later. Professor Segar moved an amendment that Mr. Hill's motion be considered next year. The amendment was carried.

Method of Elections.—On the motion of Dr. Thomson seconded by Professor Easterfield it was resolved: "That a committee of three

members be set up to examine systems of election and to recommend an improved system for the election of Fellows and of Honorary Members, the Committee to report to the Standing Committee, and that the Commitee consist of Professor Segar, Professor Sommerville and Dr. Thomson (convener).

Arthur's Pass.—On the motion of Dr. Cockayne seconded by Mr. Hill it was resolved: "That the Department of Lands be informed that it is not merely the forest near Arthur's Pass that should be made a Scenic Reserve, but also the open ground on the actual Pass itself, such ground being famous for its alpine plants.

Abstracts of Papers.—On the motion of Professor Worley seconded by Professor Segar it was resolved: "That the Standing Committee be instructed to enquire into the possibility of publishing abstracts of papers published outside the Dominion by workers in New Zealand."

Research Grants.—On the motion of Dr. Farr seconded by Mr. Wright it was resolved: "That in order to avoid unnecessary delay it be a recommendation to the Government that applications for research grants which have been approved by the Research Grants Committee and by the Standing Committee of the New Zealand Institute be placed promptly before the Minister."

Dr. Cockayne Honoured.—On the motion of Dr. Thomson it was unanimously resolved: "That this meeting congratulates Dr. Cockayne on the three recent honours conferred on him: The Mueller Medal, Honorary Membership of the American Botanical Society, and Honorary Membership of the Finland Botanical Society."

Election of Officers.—President, Dr. J. A. Thomson; Hon. Secretary, Mr. B. C. Aston; Hon. Treasurer, Mr. M. A. Eliott; Hon. Editor, Mr. J. C. Andersen; Hon. Librarian, Professor Sommerville; Hon. Returning Officer, Professor H. W. Segar.

Managers of Trust Accounts.—Mr. B. C. Aston and Mr. M. A. Eliott.

Research Grants Committee.—Professor Farr (Convener), Professor Speight, D. Hilgendorf, Dr. Denham, and Mr. A. M. Wrgiht.

Hector Award Committee.—Dr. Chilton and Mr. G. V. Hudson.

Hamilton Award Committee.—Dr. Marshall and Dr. Thomson.

Library Committee.—Professor Sommerville, Professor Kirk, Professor Cotton and Dr. Thomson.

Finance Committee.—Mr. Wright, Hon. G. M. Thomson, Professor Segar, Messrs. Eliott and Aston.

Votes of Thanks were accorded to the President, Hon. Editor, Hon. Secretary, Hon. Treasurer and Assistant Secetary; also to the Council of Victoria College for continuing to house the Library and Office, to Professor Kirk for the use of his room for the meeting, to

the Dominion Museum for use of room, and to the Press for its attendance.

Travelling Expenses.—It was resolved that travelling expenses be paid.

Dr. A. W. Hill.—Just prior to the afternoon tea adjournment, a visit was received from Dr. A. W. Hill, Director of the Royal Botanic Gardens, Kew, accompanied by Dr. Marsden, Secretary of the Department of Scientfic and Industrial Research.

Dr. Hill is visiting Australia under arrangements made by the Empire Marketing Board and the New Zealand Council of Scientific and Industrial Research invited him to extend his itinerary so as to include New Zealand.

After afternoon tea the Board resumed, and the President, in welcoming Dr. Hill, said it gave him great pleasure to inform Dr. Hill that he had that day been elected an Honorary Member of the New Zealand Institute. Dr. Hill thanked the Institute for the honour conferred upon him, and stated that he was very glad of the opportunity of meeting members of the Board of Governors. He gave an interesting outline of his career as a Botanist, and later joined in a general discussion of botanical matters in New Zealand.

PRESIDENTIAL ADDRESS.

By B. C. Aston, F.I.C., F.N.Z. Inst.

Gentlemen of the Board of Governors:—

My first sad duty is to refer to those of our members who have died during the year.

Governor.—Richard Francis Bollard, M.P., born 1863. Minister of Internal Affairs since 1923. He sat in Parliament continuously since 1911. He was one of the most beloved members in the House, and was always sympathetic towards the applications of the New Zealand Institute. He was especially interested in bird-protection.

Honorary Members:—

Georg Ossian Sars, born 1837, for many years Professor of Zoology in Oslo (Christiania). He was eminent as a marine biologist, was an authority on Crustacea, and did much work on the New Zealand species. He corresponded freely with the workers in that group in New Zealand. He was elected an honorary member in 1902, and died 9th April, 1927.

A. Liversidge, F.R.S., born 1847. He was a student of Frankland, Tyndall and Ramsay. He was in 1873 elected to the Chair of Chemistry at Sydney University, a position which he held until 1908. He excelled as an organizer, originating the Faculty of Science at Sydney University and the Australasian Association for the Advancement of Science. His research work was in the domain of descriptive and experimental mineralogy. Few men have done more to advance science as a whole in Australia and New Zealand than Liversidge. He was elected honorary member in 1890, and died 26th September, 1927.

Fellow:

Percy Gates Morgan, M.A., born in 1867. He was Director of the New Zealand Geological Survey; was at one time a member of this Board, and was elected a Fellow in 1922. He was an indefatigable worker, and in spite of much administrative and editorial duty in the Department, found time to write many papers, covering a wide range of subjects, all of which are characterised by an unusual thoroughness and attention to detail. He died in December, 1927.

Members:—

Joseph William Poynton, born 1861. He was a magistrate who took a keen interest in scientific matters, especially those relating to geology and botany. He was successively Public Trustee and Secretary to the Treasury.

Sir Henry Brett, born 1843. He was a successful Auckland publisher, not only of newspapers, but of educational books and periodicals, exhibiting a high quality in the workmanship.

David Goldie, born 1842. He was a successful contractor who will be remembered from his gift to the City of Auckland of the beautiful kauri forest which bears his name, and a bequest of a thousand pounds to the Auckland Institute.

Peter Goyen, born 1845. He was a busy Inspector of Schools, but found time to study the natural history of Otago, and particularly the New Zealand spiders, upon which he contributed several papers to the Transactions.

Charles William Purnell, born 1843. He was an Ashburton lawyer and journalist; he wrote two books on law, and contributed several papers to the Transactions.

John Hardcastle, Timaru, contributed papers to the Transactions on Geological subjects in the early volumes, and published a booklet on the Geology of South Canterbury.

T. V. Hodgson, of the Plymouth (England) Science and Art Museum; he was a member of the "Discovery" expedition.

Charles Oliver Mules, D.D., born 1837. He was Bishop of Nelson, and took a keen interest in the Nelson Institute.

Publications.

The event of the year has been the successful issue of the *Transactions* as a quarterly journal. It was not to be expected that the change-over from the Government Printer, with his highly trained staff and exceptional facilities, to a private firm could be effected without considerable trouble and some deterioration in the quality of the workmanship. Difficulties now appear, however, to have been successfully surmounted, and it is confidently expected that the quality will rise to a high level, and the speediness with which the papers are published will make the *Transactions* the best medium for publishing original, purely scientific matter in Australasia. If authors will only take more care in the preparation of their papers it will greatly facilitate the publication, lighten the heavy duties of the Honorary Editor, and decrease the cost of publishing, which is the heaviest charge the Institute has to face. The cost of typewriting is so small that there is no reason why authors should not have their manuscripts retyped until a perfectly clean copy is available for the Honorary Editor.

As an example of what can be done where the author does his best to assist, there is a fifty page paper on *Polyporaceae*, the last manuscript of which was received on 21st August by the Editor, and the finished paper was issued separately with eleven pages of process blocks containing 20 figures on 18th October in the same year. There are other instances of shorter papers being published within six weeks of their receipt by the Editor. I notice some blank pages inside the covers of parts 1, 2, and 3 of Volume 56. These might well be used for enumerating the standard works on New Zealand science, such as the publications of the Board of Science and Art, the Department of Scientific and Industrial Research, and the Lands Department.

In connection with publications, one must record satisfaction at the successful publication of the Canterbury Philosophical Institute's *Natural History of Canterbury.* It is hoped that this example will stimulate other incorporated societies to undertake similar work.

Suggested Amendment to the New Zealand Institute Act, 1908.

There are several directions in which the New Zealand Institute Act could be amended with great advantage to the working of the Institute.

The date of the Annual Meeting must, by Section 8, be held in the month of January. This often means that Members of the Board must break their holidays to journey to Wellington, or some distant centre, in order to be present at the meeting. It also throws on the officers' shoulders the extra work of bringing the books up to date, compiling, typing reports, and auditing accounts at a time when the staff and officers are struggling to get the ordinary work finished before the holidays. The result is that the quality of the work suffers. Another disadvantage is that the financial reports of the chief incorporated society (Auckland) are nearly a year old when received at the meeting. By having the financial year terminated on 31st March of each year this would bring the Institute's financial year into line with that of the Government and of the Auckland Institute. The Annual Meeting could then be held in May, or some time during the New Zealand University midwinter (short) vacation—a time which would probably suit professors.

Another amendment which should be made is the addition of provision for the appointment of a Vice-President, who should be eligible for reappointment year by year, and should be resident in Wellington. This would enable the high honour of President to be distributed without regard to the locality of his residence. The Vice-President could be left to act as the President's deputy on occasions when it is inconvenient for the President to act in person.

Section 2, which incorporates the societies forming the New Zealand Institute, requires redrafting, eliminating such societies as have become defunct, and I think making provision on the increase in active membership for any society now only sending one representative governor to send two.

I consider an effort should be made when opportunity offers to meet Sir Frank Heath's objection that the medical and engineering professions are not adequately represented on the board. Dr. Chilton, who is a Government appointee, might be said to represent medicine, and when a vacancy occurs the Government might consider the propriety of appointing someone who would represent the engineering professions.

Papers of a distinct interest for the medical profession are published from time to time in the *Transactions,* and one notices of late an increase in the number of published papers on chemistry and physics.

Now that the New Zealand Institute matters are attended to in the Government by the Prime Minister, as Minister in Charge of the Scientific and Industrial Research Department, it might be as well to amend the New Zealand Institute Act to make the Prime Minister a member of the Board of Governors.

I must again call attention to the desirableness of consolidating the statutory enactments regarding the New Zealand Institute, and incorporating the Clause 7 (1) of the Finance Act, 1925, under which authority the main income of the Institute is derived.

Finance.

The year has been such a busy one that the Finance Committee appointed at the last Annual Meeting has not been called together, but I would ask for its reappointment in the hope that it may evolve some method of augmenting the yearly income of the Institute. Provision should be made for the publishing of a decennial index of the *Transactions* on the completion of Volume 60, and the work of indexing should be begun next year.

Publication expenses are growing, the Library is growing, and the responsibilities of the Institute are growing. All call for provision for the future. One may look for a flood of original matter for publication, due to the increased sums being spent on research by the Government, and by educational institutions. The Institute must put itself in a position to accept for prompt publication any really worthy matter whether in the form of a paper in the *Transactions*, or as a Bulletin, or as a Memoir. If such matter is refused owing to lack of funds, the Institute will lose the high reputation it at present holds as a publishing medium. The Editor should certainly call upon such of the members who are in the habit of publishing in English or foreign journals to exhibit their loyalty to the Institute by publishing in the New Zealand *Transactions* concise abstract and reference of their work. The publication of abstracts of all work on New Zealand subjects published beyond New Zealand should be the work of a Committee of Abstractors. I think it would be well if abstractors for, say, Botany, Zoology, Chemistry, Geology, and Physics could be appointed at this meeting.

I should like to acknowledge the generosity of the Cawthron Institute and the Geological Survey Department for contributions to the cost of printing articles from members of the staffs of these institutions. Such action might be followed by other Departments, the members of which contribute papers costly to print.

Wealthy individuals of this comparatively small community might be asked to help the Institute financially. Their comfort and amusement is largely catered for by modern inventions, made possible by scientific research--motor-cars, gramophones, telephones, wireless sets, and electrical services. Their very wealth is possibly due to the physicist who first studied the phenomena attending the expansion and contraction of gases, and the chemist who first made superphos-

phate. I make bold to say that there are hundreds of cultured and wealthy citizens of this country who not only never make a donation to the Institute, but are not even members of any incorporated society. Perhaps they have never been approached. The creation of a body of patrons of the New Zealand Institute, each of which might pay according to his inclination, but everyone something, might be a means of increasing the income of the Institute. Such patrons contributing more than 21s. would, of course, be entitled to the annual volume.

Preservation of Natural Monuments.

The desirableness of recreating the position of Superintendent of Scenic Reserves has been the subject of a motion by this Board in the past, and the necessity for such an office must be apparent to all who have the preservation of typical areas of New Zealand primitive vegetation at heart. Some broader outlook than the mere preservation of vegetation is, however, desirable. I consider that some office or duty should be instituted, not necessarily entailing the appointment of new officers, but rather the creating of new duties to be appropriately laid on the shoulders of resident local officers, whose duty it should be to safeguard for posterity what are called in other countries natural monuments.

Some instances may make my meaning clearer. Near Fortrose, Southland, in Waikawa Bay, is a fossil forest which is washed by the sea at high tides. Similarly at Moeraki Beach, Otago, are the most perfect concretions in the world, known as Moeraki Boulders. Hundreds of these smaller boulders have been taken away to ornament Dunedin gardens. The Sandymount basaltic pillars are perhaps the finest in New Zealand. These three southern instances are geological features which it should be sought to preserve. Being on the sea frontage and Crown property, there is not the same difficulty in preserving the sites that there would be if they were on privately owned land, although in England recently a large area of valuable building-site land on the South Coast Downs has been preserved by public subscription. An instance near Wellington are the truly wonderful raised beaches at Turakirae. Another instance may be noted in the lava fields and volcanic cones at Auckland city. Such geological monuments as these stand in danger of being converted into stone quarries, or at any rate of being seriously damaged by the careless or thoughtless.

The vegetation features are, of course, more numerous, but suitable areas near all the chief towns or cities of typical primitive vegetation should be preserved. One need only to look at the beautiful town of Taihape to realise what a great asset its readily accessible reserve of black pine forest is to the citizens.

I consider that in default of a Government Department seriously taking up such a work of the preservation of natural monuments, a Committee of this Institute might be set up to report on the whole matter.

One must express satisfaction at the efficient administration of the Kapiti Island sanctuary, the Advisory Committee of which includes Professor Kirk. A visit to other sanctuaries and reserves by a representative of this Board might be productive of much good.

It is now my duty and regret to vacate the office of President, and in so doing I take this opportunity of placing on record my thanks to the Governors, and especially to those members of the Standing Committee who have helped me with the aid of their great knowledge and experience to carry on the business during the past two years.

To the officers, and especially to Miss Wood, I have been truly indebted for much painstaking work cheerfully performed.

TRANSACTIONS.

TRANSACTIONS

OF THE

NEW ZEALAND INSTITUTE.

New Zealand Bangiales (*Bangia, Porphyra, Erythrotrichia* and (?) *Erythrocladia*).

By Robt. M. Laing, M.A., B.Sc., F.N.Z Inst.

[*Read before the Philosophical Institute of Canterbury, 7th December, 1927; received by Editor, 9th December, 1927; issued separately, May 10th, 1928*]

Plates 1-15

CLASSIFICATION OF THE BANGIALES.

The order Bangiales is divided into three families (Rosenvinge 1909, p. 56), (1) the Bangiaceae, gonidia arising by division (or also without division from a mother cell, originally vegetative, (2) Erythrotrichiaceae, gonidia derived from special monospores, separated by an incurved wall from a vegetative cell, (3) Goniotrichiaceae, gonidia formed without a cell division.

We are concerned at present with the first two families only, which are thus subdivided into genera (certain non local genera are omitted).

(1) Bangiaceae.

Frond filiform	*Bangia*
Frond flattened	*Porphyra*

(2) Erythrotrichiaceae

(1) Frond erect filiform	*Erythrotrichia*
(2) Frond consisting of creeping branched filaments more or less confluent to a monostromatic disc	*Erythrocladia*

The following species are described for New Zealand:—

Bangia fusco-purpurea (Dillw.) Lyngbye.
A new record for New Zealand.

Porphyra columbina Mont.
P. nobilis J. Ag. is reduced to a synonym of this species.

Porphyra subtumens (J. Ag.) Lg.
This species formerly represented by a *nomen nudum* is now described for the first time.

P. umbilicalis (L) J. Ag. var. *Novae Zelandiae* Lg. var. nov.
To replace, *P. vulgaris, P. laciniata,* and *P. perforata,* previously described from New Zealand.
Erythrocladia (?) *insignis* Lg. (sp. nov.)
Erythrotrichia ciliaris (?) (Carm.) Batters.
A species of questionable identity.

BANGIACEAE.

Frond filiform *Bangia.*

INTRODUCTORY AND HISTORICAL.

Two species of *Bangia* (*B. ciliaris* Carm. and *B. lanuginosa* Hook. f. et Harv. 1855 ii. 264) are described for New Zealand in Hooker (1867) p. 716. *Bangia ciliaris* is now *Erythrotrichia ciliaris* (Carm.) Batters; and will be further considered under that genus. *B. lanuginosa* Hook. f. et Harv. (1855) ii. p. 264 has not again been identified and the original description is so meagre that it is not likely I think to be rediscovered. It is probably indeed merely a young form of the species *B. fusco-purpurea* (Dillw.) Lyngb. now to be recorded for the first time from New Zealand. *B. lanuginosa* is described from specimens collected by Colenso as "parasitic on *Chordaria,*" no locality is given, but it would probably be the east coast of the North Island where most of Colenso's species were obtained.

Bangia fusco-purpurea (Dillw.) Lyngb. (1819) Hydrophyt. Dan. p. 83.

In its fresh water form this species is known as *B. atropurpurea* C. Ag. J. Ag. (1882) p. 36 treats *B. fusco-purpurea* as a variety of *B. atropurpurea* I quote his description for the benefit of New Zealand students. *B. atropurpurea*, purpureo-violacea elongata, stratum effusum in rupibus et lignis efficiens, filis junioribus cylindraceis rectiusculis, singulis, conspicue articulatis adultioribus incrassatis curvatis areolatis, articulis in cellulas quarternas pluresque, demum numerosas et fere sine ordine conspicuo juxta-positas divisis, endochromatibus in filo adultiore densius farctis, spatiis intercedentibus hyalinis angustis vix conspicuis var. *B. fusco-purpurea* saepe valida, marina colore dilutius aut obscurius purpurascente.

There are a number of forms of *B. fusco-purpurea* and several closely allied species; however, I do not intend at present to discuss details, but merely to record this widely distributed aggregate species from New Zealand waters. It is known from the North Atlantic, Mediterranean, Californian, and Tasmanian coasts.

Localities: On a drifted log between tide marks, Homewood, Pelorus Sound (Sept.); on the pier New Brighton, near high-tide mark (June), Dunedin, and elsewhere.

Frond flattened *Porphyra.*

INTRODUCTION.

Amongst the seaweeds of commercial importance the genus *Porphyra* occupies a high position. Species of this genus are widely

used as a food, as a medicine, as a delicacy. In Japan they are cultivated, in Great Britain under the name of Purple Laver or Sloke they are regularly sold, as also under different names in Japan, Hawaii and California. It is therefore a matter of some importance, commercial as well as scientific, to ascertain the actual species existing in New Zealand. This is not easy, mainly owing to the fact that some of the earliest investigators, after a cursory examination, frequently assimilated species occurring in New Zealand with distinct European species; and it is now almost impossible to determine, without access to the original specimens, what were the New Zealand species appearing under European names. It is not proposed here to undertake a complete investigation of the New Zealand forms; but merely to examine them with sufficient care and detail to enable them to be assigned definitely to their proper positions.

The first difficulty that the investigator meets is the absence of any general agreement amongst algologists as to the exact systematic position of the family or group. That need not detain us long here, as it will be sufficient for our purposes, if it is clear that we are dealing with plants usually placed in the group.

By older writers it was usually placed among the Ulvaceae, where it still appears in J. Agardh (1882) p. 38. However, Le Jolis (1864) p. 99 following Thuret had already placed it before the Florideae; and in this position it is usually now to be found, in the group Bangiales, accompanied by various other genera. Oltmanns (1922) Band II s. 230 places the Bangiales outside the Rhodophyceae, but just prior to them. (The name Phaeophyceae in Oltmanns occurring at the top of the page, is doubtless there as the result of an oversight). It has to be admitted, that *Porphyra* with its purple endochdrome, carpospores endowed with amoeboid motion, and intercalary growth is very different from any true Floridean; but until a better place can be found for the group, it must remain here. The absence of protoplasmic inter-cellular strands is another feature distinguishing the Bangiales from the true Rhodophyceae. It is now our purpose merely to describe in some detail the species hitherto assigned (rightly or wrongly) to the genus *Porphyra*, and occurring in New Zealand waters.

The genus is widely distributed in all temperate and colder seas. In 1897, Engler and Prantl. p. 312, recognised only 20 species, and considered the genus to be cosmopolitan; but since then many fresh species have been described, and the older species have been better delimited, so that now there are probably at least fifty recognized species, and it appears that some which were at one time thought to be cosmopolitan have a much narrower area of distribution than was previously believed. The species are often difficult to discriminate without close examination. Hence much confusion has arisen with regard to them; and this as will presently be seen has been the case especially with our New Zealand forms related to *P. umbilicalis*. Apparently there are tropical areas from which the genus is absent; and the type species *P. umbilicalis* (L) J. Ag. at one time thought to be found in all seas, was later, after closer examination, regarded as confined to the North Atlantic. Still further examination has again extended its range to the extra-tropical seas of both hemispheres,

North Atlantic, North Pacific, Cape of Good Hope, South American, Sub-Antarctic, etc. I now propose to regard the New Zealand plant as a variety of this nearly cosmopolitan species.

Earlier investigators were content to describe the species of this genus in terms of colour, consistency, shape, and general appearance. Hence the original belief in their cosmopolitan nature. But later investigators showed that these characters were subject to so much modification, dependent on ecological conditions and the treatment of specimens, that they were for the most part unreliable for the discrimination of species. Subsequently during re-examination the tendency was to limit specific areas, and these again are now tending to be widened with the increase of more definite knowledge. Thus it again appears to be probable that *P. umbilicalis* (L) J. Ag. is an almost cosmopolitan plant; and probably in all its forms valuable for food.

Engler and Prantl (1897) p. 308 give as one of the chief marks of the Bangiales a single star-shaped chromatophore with a central pyrenoid. In most of the New Zealand forms the pyrenoid is with proper treatment quite readily visible; but it is by no means evident that the chromatophore is always star-shaped. Usually the single chromatophore fills the whole lumen of the cell, though at other times with different treatment it shows an irregular margin. In *Porphyra subtumens* it is somtimes granular in appearance; but it has not yet been clearly ascertained that the granules are discrete, and so the species has, for the present at any rate, been left within the genus. No attempt has been made in this investigation to make a detailed or cytological study of the cell contents, consequently they will not be further dealt with here. It is usually considered that the chromatophore contains both phycoerythrin and phycocyan, thus giving to *Porphyra* its purplish colour. But this colour varies much with the age, state, and environment of the specimen. New Zealand forms in the fresh state are often of a dark translucent sherry-colour when viewed by transmitted light; but a brown black as they hang glistening from the tidal rocks. The colour changes when the plant is dried and preserved in a herbarium, and goes through a large number of more or less indefinable shades, tan, purplish, wine-red, plum-colour; and it is unfortunately chiefly from herbarium specimens that the colour has been described. In some cases after the plants have been dried for a time, the colour is sufficiently determinate to be of value for diagnostic purposes; but it must always be used with caution for this end.

Similarly in respect to the form. This, though to some extent characteristic, varies with the age, habitat, and other circumstances of the plant, and is in itself insufficient to determine the species.

History.

(A) The first species known from New Zealand was *P. columbina* Mont. from the Auckland Islands. (Montagne in D'Urville 1845, p. 33). There can be little doubt that this is the common *Porphyra* throughout New Zealand and the adjacent islands.

(B) Harvey in Hooker 1867, p. 715 following on his work in the *Flora Novae Zelandiae*, and the *Flora Antarctica*, lists three species.

(1) *P. laciniata* Agardh.
(2) *P. vulgaris* Agardh.
(3) *P. capensis* Kuetzing.

(1) *P. laciniata* = *P. umbilicalis* (L) J. Ag. f. *laciniata* (Light.) Thuret in Le Jolis' Liste (1864), p. 99—is a form of the common *Porphyra* of the North Atlantic and Mediterranean.

(2) *P. vulgaris* = *P. umbilicalis* (L) J. Ag. f. *vulgaris* (Ag.) Thuret in Le Jolis' Liste, p. 99. This is also one of the forms of the common North Atlantic species.

(3) *P. capensis* Kuetzing is a South African plant, here wrongly identified with *P. columbina* Mont. Harvey further states (*loc cit.*) that *P. vulgaris* and *P. capensis* occur together and are probably not different. It will be seen that Harvey deletes the original good species, *P. columbina* Mont., and inserts three species, two from the North Atlantic and one from the Cape of Good Hope. Now, as already has been noted, it was the tendency in recent years for algologists to restrict *P. umbilicalis* (L) J. Ag. in its various forms, *P. vulgaris*, *P. laciniata*, *P. linearis* to Northern waters; but we certainly have a form in New Zealand which closely approaches *P. laciniata*, and other plants can be found which in most respects match *P. vulgaris* and *P. linearis*. However, our plant presents minor differences. It seems therefore wiser to describe our form under a varietal name, viz., *P. umbilicalis* (L) J. Ag. var. *Novae Zelandiae* Lg. This is the more necessary as there is in constant association with the New Zealand plant in the same thallus, and to the ordinary eye quite indistinguishable from the *Porphyra*, a plant of a distinct genus, which I am naming *Erythrocladia* (?) *insignis*.

Thus though we have in New Zealand the common English *Porphyra* known as the "purple laver," and used as a popular remedy in England and Scotland for scrophulous cases, as a delicacy, and as a food by the poorer fishing classes, it has associated with it commensally and usually forming a large portion of thallus, a plant of a different genus, which may have different properties. It is thus impossible to obtain here purple laver in its pure form. I do not know what is the food value of the compound *Erythrocladia-Porphyra* fronds; but possibly they will be found to be quite as acceptable and just as useful as those of the true *P. vulgaris*.

(C) J. Agardh (1877) p. 1, following Harvey lists *P. vulgaris* and *P. laciniata* only; but in (1882) p. 62 he created the new species *P. nobilis* for New Zealand, though he did not state if it was to replace one of the previously recorded species or not. I hope to show later that *P. nobilis* is only a form or state of *P. columbina*, and that the name must disappear, or appear only as a slight varietal state of the latter species. *P. nobilis* J. Ag. is founded on specimens collected by Dr. Berggren "ad oras Novae Zelandiae." J. Agardh (*loc. cit.*) further revives Montagne's *P. columbina* for other specimens collected on the coasts of New Zealand, and the adjacent islands by Berggren.

(D) In 1899, Laing p. 61 following Agardh 1882 p. 62, records from New Zealand, *P. nobilis,* and *P. columbina*; and drops the North Atlantic forms of *P. umbilicalis* (L) J. Ag. recorded by Harvey, and in the Addendum No. 389 records *P. subtumens* J. Ag. (mscr.). This is a *nomen nudum* and is described later in this paper for the first time.

(E) Then in 1909 p. 503, Laing records for the Sub-Antarctic islands of New Zealand:—

(1) *P. perforata* J. Ag.
(2) *P. nobilis* J. Ag.
(3) *P. columbina* Mont.

P. perforata J. Ag. is a plant from the North Pacific, fully described by Hus (1902) p. 202. It is best known from California, but occurs North to Alaska and again probably on the north-east Asiatic coasts. The plant was identified for me (somewhat doubtfully) by A. Gepp, as occurring in the Sub-Antarctic Islands of New Zealand. "Whether *P. perforata* is right for the Campbell Island specimens, I cannot say for certain. It is as near as I can get at present." (Extract from letter from A. Gepp under date November 24th, 1908). Later Prof. Setchell assured me that the plants corresponded exactly in external appearance with the North Pacific forms of *P. perforata.* Hence I have hitherto enumerated them as such, and as replacing the *P. laciniata* of Harvey. Closer examination enables me to state that they are not *P. perforata.* Whether this is the form described by Harvey as *P. laciniata* J. Ag. it is impossible to state with certainty, without access to the original specimens, but it is the only species on New Zealand shores commonly laciniate, and would almost certainly be in Harvey's herbarium. However, Harvey obviously gave the New Zealand *Porphyras* enumerated by him only a cursory examination. Thus he says of the Auckland Island forms, Hooker (1844) p. 193, that *P. columbina* differs from *P. vulgaris* in the rigid texture of the frond, and without further comment identifies it with the South African *P. capensis.* Similarly he identifies the New Zealand forms, Hooker (1855) p. 264, as *P. laciniata* J. Ag. and *P. vulgaris* Ag., but gives no detailed description.

(F) In 1926, Laing following his previous determinations records in his list of marine algae the following species p. 146:—

145. *P. columbina Mont.*
146. *P. nobilis* J. Ag.
147. *P. perforata* f. *lanceolata* Setchell and Hus.
148. *P. subtumens* J. Ag. (*nom. nud.*)

It is proposed now to show that *P. nobilis* is only a synonym for *P. columbina*; and, as already stated, that *P. perforata* is distinct from the New Zealand plant, and to provide a description of *P. subtumens.*

Key to New Zealand Species of Porphyra.

P. columbina, cystocarps large containing up to 256 or more carpospores, monoecious.

P. umbilicalis, var. *Novae Zelandiae,* cystocarps containing normally 8, but sometimes 16 carpospores, monoecious.

P. subtumens, epiphytic or parasitic on D'Urvillea, cystocarps with 16 to 32 carpospores, monoecious.

P. columbina Mont.

Synonyms.

P. capensis Kuetz.; Harvey (1847) i. p. 193; Harvey 1867 p. 715.

P. nobilis J. Ag. (1882) p. 62; Lg. (1899) p. 61, No. 35; Lg. (1909) p. 504; Lg. (1926) p. 146, No. 145; de Toni e Forti (1923) p. 13.

P. vulgaris, Harv. (1855) ii. p. 264. (?) *P. Kunthiana.* Kuetz. Phyc. gener. p. 383.

I quote the description of Montagne with some of his comments, as it is rather inaccessible and as it will be necessary to refer subsequently to various points in it.

Porphyra columbina Mont.

P. frondibus gelatinoso-membranaceis aggregatis parvulis purpureo-violaceis, columbinis, orbiculatis crispato-undulatis granulis sub-quaternis. *P. columbina* Montag. Prodr. Antarct. p. 14; Endl. *l.c.* p. 19 Hab. in oris Aucklandicis ab ill. D'Urville inventa. *Desc.* Frondes ex una basi dilatata disciformi plures in caespitem congestae, tenuissime membranaceae, gelatinosae, orbiculares sesquipollares, margine lacero-crispato undulatae, minutissime regulariter violaceo-punctatae, et sporidiis purpureis in acervos orbiculatos collectis aut effusis granulatae. Structura cellulae ampiae bina granula violacea quarum singulum utriculo proprio inclusum videtur, foventes et ordine quaterno saepius dispositae. Sporidia granula nutritione s. vegetatione praeter modum aucta, 2-4 plo. crassiora accreta simul confusa purpurea sorosque effusos imprimis ad margines efformantes substantia tenuis, membranacea gelatinosa facillime dilaceranda. Chartam cui causa exsiccatione imposita fuit, conchyliatam ad ambitum amoene rediit eique praterea arctissime adhaeret.

J. Agardh (1882) p. 70 gives the following diagnosis.

"*Porph. columbina* (Mont. Prodr. phyc. ant p. 14) rupicola membranacea ex livido violacea pluripollicaris, fronde juvenili sessili supra basem reniformiter expansa obovato—oblonga marginis undulatis lobatisque, demum distromatica endochromatibus quaternatis quadrigeminis invicem distantibus, tetradibus limbo latiore ipsorum diametrum conspicue superante a proximis separatis, glomerulos sporidiorum singulis verticaliter elongatis, suo diametro plus duplo longioribus."

Neither of these descriptions is sufficient for present-day requirements and will have to be supplemented. Two points in Montagne's accurate account misled subsequent investigators. The first is his statement that the plant is small, only an inch and a half in length. Obviously the specimens collected by D'Urville were young or dwarfed, and other investigators looking for a small tufted form have overlooked the abundant specimens of *P. columbina* growing everywhere on the rocks between half-tide and high-tide marks on the open coast and in harbours throughout New Zealand. Another fact which no doubt has led to the same oversight was the original dis-

covery of the plant at the Auckland Islands, hence the tendency to overlook its existence in New Zealand.

The plant does not usually adhere firmly to paper or discharge its colour, as stated, by Montagne, unless it is slightly decayed. Agardh points out that he himself has not seen the small tufted orbicular, purple violet fronds described and depicted by Montagne,* but suggests quite correctly that the form and magnitude may vary.

The chief error in Agardh's description is his statement that the frond is two-layered (distromatic). It seems probable from his figures that his error has been due to his making of a section through the reproductive portion of the frond. (Tab. 11, fig. 65, t and 66 *loc. cit.*). These figures certainly suggest a section through the cystocarpic portion of the frond. The marked division between the upper and lower layer is the first reproductive division in the cystocarp, which remains permanent and well marked throughout subsequent changes.

Species of *Porphyra* that are distromatic are placed by De Toni (1890) Syll. IV. p. 20 in the genus *Wildemania*; and in this he has been followed by a few algologists, but many do not recognize the distinction. However, I have not as yet found any distromatic species of *Porphyra* in New Zealand.

Having thus, as far as I can, cleared up the chief points of difficulty in nomenclature, it remains now to give a more detailed account and description of *P. columbina* Mont.

The Thallus.—The plant grows from a small fleshy umbilical disc a mm. or two in diameter; and gives rise to a number of long linear fronds with undulate crisped and folded margins, entire and slightly lobed (Fig. 1).† The outer ends of the fronds are soon worn or torn off, and the fronds expand in breadth, so that we get a number of broad tufted, often folded fronds of somewhat irregular shape. These are usually much broader than high, so that the whole plant when pressed flat upon paper becomes approximately circular in outline, and is 10 cm.—20 cm. across (Fig. 2). In this form it is common in spring and early summer on rocks from high to about half-tide marks. It is not found in pools. As it grows older it may lengthen somewhat, and become more irregularly cut and lobed (Fig. 3), and assume a greater variety of shapes. The margin is usually crose or entire, but sometimes bears short blunt protuberances, simply forked, or papilliform. The long, narrow linear forms are to be found (near Christchurch) in August and September, along with a few of the previous year's plants, which usually occur near high-water mark, where they have been subjected less to the violence of the waves. The plant is, when fresh, olive-brown to green with reddish-brown margins in the sporocarpic area. It has less of the tan colour than is to be seen in *P. umbilicalis* var. *Novae Zelandiae*, but is similar to it in general appearance, with, however, a more crisped and irregular margin.

* I collected mature plants exactly corresponding to Montagne's description at Moeraki in May, 1926.

† The photographs and micro-photographs are by Mr. C. M. Gray.

In smoother water and in suitable positions, e.g., where pendent from an overhanging rock and swayed by the tide, it may grow to a considerable length and become fairly regularly oblong. Occasionally through being torn, it may become somewhat laciniate; but this is not its characteristic form, as it is that of the following species *P. umbilicalis* var. *Novae Zelandiae*. In quiet waters, such as those of a river estuary, it may reach 70—80 cm. in length, with a breadth of 30 cm.—40 cm. As it grows older and starts to decay, the olive green becomes more pronounced, the brown fades out, and after passing through a dirty sherry colour, it becomes green enough to be mistaken for a decaying *Ulva*. It is at certain stages very similar to *P. umbilicalis* var. *Novae Zelandiae* in appearance, and on the rocks can often scarcely be distinguished from it. Both in masses are dark brown-black, but there is usually more green in *P. columbina* than in *P. umbilicalis* var. *Novae Zelandiae*. When dried and kept in a herbarium for a few months, it changes to vandyke brown, passes through a port-wine shade to a plum colour, or even to a lilac shade. It was this last shade that impressed Montagne and led to its specific name. Unfortunately, neither Agardh nor Montagne ever saw the plant growing, and so their descriptions of the colour must be taken to apply to the dead plant. The thallus is brighter and redder towards the margin where there are masses of cystocarps, and a dirty white when there are patches of antheridia. But even in a herbarium specimen one may find in the vegetative portion abrupt changes of colour from a dull yellow or brown to a purple, without apparently any change whatever in structure. This change does not, as it usually does in *P. umbilicalis* var. *Novae Zelandiae*, indicate any passage from one member of a commensal pair to another. It is possibly due to varying amounts of moisture in different parts of the frond.

As it lies on the rocks, the thallus often becomes perforated: and as it becomes older, duller in colour, passing through a number of colours, until it reaches the dirty olive-green already referred to. It may be found at all seasons of the year from high-tide down to half-tide. It requires exposure to the air, but after a hot, dry summer it largely disappears from the rocks and either cannot be found at all, or only under overhanging faces. From September to January it may usually be found in immense masses covering the boulders and ledges, providing very insecure foothold for the walker, and constituting the chief vegetation of the area.

Structure.—At the base, which is often paler than the rest of the plant, occur the typical rhizines, which closely compacted form the disc, consisting of the massed hyphal ends of the lower cells of the fronds. The disc is often more or less umbilical. The vegetative cells are usually highly characteristic, and generally enable the species to be determined from a patch of frond a few millimetres in area; but the shape and size of the cells and breadth of the surrounding gelatine vary considerably with the age of the plant, the position of the area relative to the base, the distance from the margin, and other conditions. As seen from the surface the irregularly-shaped endochrome fills nearly the whole of the lumen and shows, when fresh, an

average length of 20 mmm.—30 mmm., and breadth 12 mmm.—25 mmm. Between adjacent chloropasts the gelatine may be 5 mmm.—10 mmm. in breadth, but in some parts of the frond is greater or less. Occasional cells of much larger dimensions may be found. The shape of the cells varies much. When young they are often found in pairs, each cell being an oval, flattened on one side with its flat side towards its sister cell, but as they grow older the shape becomes more irregular, until they become oval, oblong, pyriform, triangular and even nearly square (Fig. 4). The distance between adjacent pairs becomes less, owing to the separation of the sister cells. Towards the margin they become slightly rounder, larger, and looser. The cell-wall at first angular, 4—6 sided, owing to pressure, becomes afterwards rounder and more curved, and finally is invisible in the gelatine. In old and decaying specimens the mucilaginous interspaces become wider, and may amount to several times the diameter of the endochrome. However, the apparent width of the hyaline margin depends much on the method of preparation, being less in fresh material than in that which has been mounted in glycerine for some time.

Towards the base the cells are usually more angled than elsewhere, and the breadth of the gelatine seen from above becomes again comparatively small.

The thickness of the thallus when measured through a vegetative portion near the margin is 45 mmm.—60 mmm.; but it becomes much thicker in the cystocarpic portions. In section, the vegetative cells in the centre of the thallus are usually regularly rectangular, and often slightly concave on the shorter sides, 10 mmm.—25 mmm. in length, the thickness of course varying considerably with the method of preparation. Though usually rectangular and about half as long as broad the shape of the cells varies in different parts of the same specimen, being at times nearly square, or irregularly contracted in places.

Towards the margin of the frond in the cystocarpic area, the cells are usually oval in section, or sometimes convex on one side and flat on the other. The measurements given are only to be used with circumspection, as those of the gelatine in particular depend to a considerable extent on the method of preparation, state, and age of the specimen; but nowhere after examining many specimens from many localities, have I found a distromatic frond.

This species is sometimes parasitized by an *Erythrocladia*, which is perhaps the same species as that found in *P. umbilicalis* var. *Novae Zelandiae* to be described more fully later. The cells of the parasite are so like those of the *Porphyra* that it is generally quite impossible to distinguish them except in fresh specimens. Invagination takes place after the fashion subsequently described in *Erythrocladia insignis*; and I have even seen the cystocarps of the *Porphyra* apparently linked up by the processes of the *Erythocladia*. A process failing to penetrate an adjacent cell may be lengthened until it is 200 mmm. or more long, though only 5 mmm. or less in breadth. The species of *Erythocladia* parasitic in *P. columbina* presents certain minor differences from *E. insignis*; but so far I have seen nothing sufficiently distinctive to justify giving it a fresh name, and for the

present the two forms must be regarded as identical. *P. columbina* is only occasionally parasitized, and then only in a small portion near the margin of the frond.

Reproduction.—The cystocarps and antheridia are scattered round the edges of the frond, and generally occupy an area of 1 cm. —2 cm. in breadth; but in older fronds the cystocarps may be found right across the surface of the frond, being much more numerous towards the margin. The antheridia chiefly occupy the marginal area for a depth of several mm. but irregularly-shaped antheridial patches are sometimes to be found in the cystocarpic regions. Quite young plants are fertile, and reproductive organs may be found at all times of the year.

Mature cystocarps as seen from the surface are 75 mmm.—100 mmm. in length and about half that in breadth, in section they are about 100 mmm. with a varying thickness of gelatine on each side depending on the method of preparation. They are broadly oval in shape and usually contain about 32 surface divisions, but this number may be doubled, perhaps owing to the coalescence of two adjacent cystocarps—usually they are 8 divisions deep — thus giving rise in some cases to as many as 512 carpospores in one cystocarp. As they become older they become more nearly circular in horizontal section, and the contents are finally aggregated without order; occasionally very large cystocarps are to be seen in which it is impossible to count the number of spores (Figs. 6, 7.)

The cystocarps are usually scattered, but sometimes closely appressed side to side, so as to form patches. The first divisions are cruciate, and remain distinct until the carpospores are almost mature. Other divisions are irregular, and are frequently more or less diagonal when seen in section. In addition to the ordinary vegetative cells, much larger and often colourless cells are inter-mixed with the cystocarps. These may be exhausted cystocarps.

The antheridial patches are quite irregular in shape; but often rim the margins for a depth of two or three mm. from the surface in the cystocarpic region and with a length of several cms. They are colourless and do not enclose vegetative cells, though an occasional cystocarp is met with amongst them. They often appear as irregular enclaves in the cystocarpic region. The antheridium at first divides into a tetrad, then subdivides forming a pair of tetrads, and in some cases four tetrads are formed, thus giving 16 surface divisions. The number of tiers is usually eight; thus giving a total number of 128 antherozoids; but fewer divisions parallel to the surface may sometimes be found. (Fig. 5.)

P. nobilis, a synonym for *P. columbina*.

Having given a fairly full description of *P. columbina,* I shall now endeavour to show that J. G. Agardh's *P. nobilis,* is only a synonym for *P. columbina.* His description is as follows (J. Ag. 1882, p. 62):—

P. nobilis (J. Ag. mscr.) rupicola membranacea sub-lilacino purpurascens pluri-pollicaris, fronde sensim inferne umbilicata, superne laciniata undulata monostromatica, endochromatibus demum

quaternatis, quadrigeminis invicem adproximatis, tetradibus limbo latiore hyalino diametrum endochromatis aequante a proximis separatis, parietibus cellularum vicinarum pressione mutua angulatis admodum conspicuis, sporidiis inordinatis plurimis glomerulos verticaliter ovales formantibus.

In comparing this with his description of *P. columbina* it will be seen that the points of difference are the following:—

P. columbina.	*P. nobilis.*
(1) Distromatic.	Monostromatic.
(2) Colour, "ex lurido violacea"	"Sub-lilacino purpurascens." *
(3) Width of gelatine. "tetradibus limbo latiore ipsorum diametrum conspicue superante a proximis separatis."	(3) "tetradibus limbo latiore hyalino diametrum endochromatis aequante a proximis separatis."
(4) Cell wall (not described).	(4) Parietibus cellularum vicinarum pressione mutua angulatis admodum conspicuis.

Now I have dealt with all these points in my description of *P. columbina*. However, I should perhaps show here that none of them is distinctive.

(1) *P. columbina*—if properly identified by me, is monostromatic and in this does not differ from *P. nobilis* J. Ag.

(2) The colour of a *Porphyra* generally varies so much according to age, state, habitat, etc., that it cannot usually be employed as a specific determinant, except cautiously in conjunction with other characteristics. Some forms of *P. columbina* are on drying lilac, others pass through purple to dark red and brown. I cannot find any colour strains sufficiently distinct to separate *P. nobilis* from *P. columbina.*

(3) The width of the gelatine surrounding the cells. This varies much, but particularly with the portion of the frond from which the area examined is taken and the age. There is little interspersed gelatine near the centre of the frond or towards the base. There is much more in old fronds and towards the margin. The character is quite insufficient to enable one to found a specific distinction on it.

(4) The angularity of the cells and the distinctness of the cell-wall. These also vary much. The angularity of the cells in the reproductive area is often pronounced and the cell-walls distinct. Their character also depend on the method of preparation of the frond, and the distinction made by J. Agardh is too slight to be of virtue for discrimination.

I consider then that *P. nobilis* J. Ag. is only a state of *P. columbina*, and therefore *P. nobilis* J. Ag. must in future be regarded as a synonym for *P. columbina* Mont. I have, through the kindness of Dr. Kylin of Lund, received two microscope slides from specimens identified by J. Agardh as *P. nobilis* and *P. columbina*; and though these

* For further discussion of colour see under *P. subtumens.*

slides do to some extent show the differences insisted upon by Agardh between the two species, I think as above shown that both slides represent only different states of the same species.

Since writing the above, I have received from Dr. G. Hamel, of Paris, to whom I sent specimens of our New Zealand Porphyras, a letter under date 26th August, 1927, which further confirms my view of the identity of the two species. A portion of the letter I quote:—"Les petits échantillons (*P. nobilis* No. 1980) correspond bien au type du *P. columbina* Mont. Je crois come vous que le grand échantillon (*P. nobilis*, No. 1952) n'est qu'une forme de la meme espèce. J'appelle le tout *P. columbina* Mont.; je pense que le *P. Kunthiana* Kutz n'en est pas different. Vous trouverez une bonne description de cette dernière espèce dans Howe Mar. Alg. of Peru. Les characteristiques sont grand épaisseur de la fronde, organes sexuels en plages melangées, spores et spermaties nombreuses, cellules vegetatives presque carrées."

As to the identity of *P. columbina* Mont. with *P. Kunthiana* Kütz, I can offer no opinion as I have no specimen of *P. Kunthiana*, nor have I access to Marshall A. Howe's work on the Marine Algae of Peru, so that the matter must be here left in abeyance. However, I have included *P. Kunthiana* with a (?) amongst the synonyms.

Localities.—Antipodes (Cockayne!) Campbell Island, Aucklands, Snares, Dunedin (Lawyer Head, Black Head, Hoopers Inlet, etc.), Moeraki, Lyttelton (Sumner, Taylors Mistake, Governors Bay, etc.), Gore Bay, Kaikoura, Wellington (Lyall Bay, Mahanga Bay, Wellington Heads, etc.). The northernmost points from which I have noted specimens is Mongonui. The plant is no doubt abundant in suitable localities all along the New Zealand coasts; but so far does not appear to have been identified outside New Zealand, unless it is identical with the South American *P. Kunthiana*.

Porphyra subtumens (J. Ag.) Lg.

This is a very distinct little species abundant on *D'Urvillea antarctica* at certain seasons of the year. Many years ago I sent specimens of it to J. Agardh at Lund, who returned it under the name of *Porphyra subtumens*, under which name I recorded it (1902), p. 358 No. 389. Apparently the species has never been described, so *Porphyra subtumens* still remains a *nomen nudum*.

Porphyra subtumens (J. Ag.) Lg.

Species Porphyrae monostromatica, monoica, endochroma, aliquando sensim granulata in *D'Urvillea antarctica* insidens, basi incolorata, cuneata, thallo expanso, rotundato, lobato, 10 cm.—15 cm. longo et lato, crassitudine 25 mmm.—35 mmm. Margine crispata, irregulariter lobata dentataque, cellulis irregulariter ovalibus, 20mmm.—30 mmm. longis, 15 mmm.—20 mmm. latis, cystocarpis a facie visis quaternis saepissime divisis, et in quattuor stratis dispositis, antheridiis a facie visis sedecim in quattuor vel raro in octo stratis dispositis.

General Description.

As I have recognised the specific name *subtumens* in my lists, though hitherto only a *nomen nudum,* I presume I must continue to use it However, I have no idea why Agardh applied the name to this plant. I can find nothing to suggest it, unless that the plant is apt to swell up and disintegrate when placed in various mounting fluids.

The Thallus. — The plant is epiphytic or possibly parasitic on *D'Urvillea antarctica* Cham. I have not so far been able to trace any further connection between the two species than the fact that the Porphyra puts out rhizines of the type normal to the genus, which penetrate into the thallus of the *D'Urvillea.* Whether they act as haustoria, I do not know. There is no apparent reason why the plant should not nourish itself.

The smallest plant examined was 2—3 mm. across, rounded in shape, and slightly stipitate, and consisted chiefly of rhizine emitting cells. The base is colourless and cuneate. Older plants are expanded into a thallus, which is irregularly lobed and toothed, and grows up to 12 cm. and 15 cm. in length and breadth. It is usually more or less rotundate in outline. It dries to a bright pink puce or red colour and adheres closely to paper, becoming much wrinkled in the process. In the fresh specimens the colour is similar to that of the dried, but not so bright as it later becomes. It is therefore quite readily distinguished from the other New Zealand species by colour alone. It is a transient summer-growing plant being found chiefly in the months October to March, and so far as I am aware not to be found at all in the winter months. (Fig. 8.)

Minute Structure.—The frond is monostromatic, and tenuous, 50 mmm.—75 mmm. in thickness in a glycerine mount; but only about half that thickness in a balsam mount, where there is no swelling of the gelatine. In section the cells are usually oval, but vary considerably, being sometimes square, sometimes twice as high as broad, round, and of other forms. They are from 20 mmm.—25 mmm. in height, with a varying amount of gelatine on each side, so that the whole section may be not more than 30 mmm.—35 mmm. in thickness. The endochrome fills the whole lumen of the cell, and sometimes but not always appear granular. It is unlikely, however, that this is the case, and the apparent granulation may be due to projections or irregularities on the surface of the chromatophore. The cells seen from the surface are irregularly rectangular-oval or rotundate about 12 mmm.—18 mmm. in length and breadth. (Fig. 9.)

Reproduction.—The plant is monoecious, and the greater portion of the frond becomes reproductive. The antheridia are 25 mmm.—30 mmm. in length and rather less in width with a maximum of 16 surface divisions, and eight layers deep. It would seem probable that the divisions of each tier at right angles to the frond takes place successively, and the spermatia in the first layer escape before the second layer is subdivided. At least the antheridia, when seen from the side, show only the eight divisions parallel to the surface of the frond, and not those at right angles to it. (Fig. 10.)

The cystocarps are rather larger than the antheridia, and show 4 to 8 surface divisions, and usually 4 in depth, thus giving 16 or 32 carpospores. They show the same characteristic as the antheridia, i.e., at first only the surface layer is divided at right angles to the frond, the three remaining tiers when seen from the side appearing undivided. (Fig. 11.)

With regard to this species Dr. Hamel writes 26th August, 1927, in a letter from which I take the liberty of quoting. "Je crois que ce que vous appelez *P. subtumens* est le véritable *P. nobilis* J. Ag. voici ce que J'en dis dans mon article [an article to be shortly published.]

"Bien que J. Agardh dise que son *P. nobilis* est rupicole, un échantillon conservé dans l'herbier Thuret (Algae Muellerianae, curante J. Agardh, distributae) et provenant du cap Saunders, New Zealand, est épiphyte. (In a foot note, "épiphyte sur un *Schizymenia*".) Comme l'indique J. Agardh, la couleur de cette espèce rapelle celle du *P. miniata*; elle est cependant d'un rouge vineux un plus foncé et plus terne. Les échantillons ont de 3 à 5 cm.; deux de'entre eux sont orbiculaires, à marge assez fortement plissées, le troisième, qui est épiphyte, est plus allongé et très enroulé en spirale.

Le tissu assez serré est forme de cellules arrondies d'environ 10 mmm. de diametre et la fronde montre une épaisseur de 30 a 45 mmm. Echantillons steriles." I would like to submit a few comments on the above. Now I think I have given sufficient reason already for regarding *P. nobilis* as a synonym for *P. columbina*, and I can see no resemblances in the above description to *P. columbina*. Consequently I cannot think that Dr. Hamel is right in considering his specimens from Cape Saunders to be Agardh's *P. nobilis*. The description on the whole, however, corresponds well with my *P. subtumens*. The small cells, the thin tissue and the colour certainly suggest this. Against it is the fact that one at least of the specimens was found growing on a *Schizymenia*. Now one would certainly expect to find *P. subtumens* on the *D'Urvillea* at Cape Saunders, but I have not seen it on *Schizymenia*, and its occurrence on species of this genus must be rare.

I have a specimen of *P. miniata* from Greenland which exactly matches in colour some young plants of *P. subtumens* from Akatore, and the ordinary colour of dried specimens of *P. subtumens* might well be described as "un rouge vineux un peu plus foncé et plus terne." It seems, too, probable that Agardh has at one time (1882) confused the two species *P. subtumens* and *P. nobilis* (= *P. columbina*); it was some years later (1900) when he named my specimens as *P. subtumens*, and probably up to that time he had placed his specimens of *P. subtumens* with those of *P. nobilis*, and had not submitted them to any close examination. There can be no doubt that the plant defined for me by J. Agardh as *P. subtumens* is the epiphyte on *D'Urvillea*, and that *P. nobilis* J. Ag. agrees in all respects with *P. columbina* Mont. except in colour. The confusion in colour no doubt resulted from the fact that Agardh had mingled the two species in his herbarium. Certainly the fragment of *P. nobilis* Ag. sent me by

Kylin is *P. columbina*, not *P. subtumens*, so I think *P. subtumens* must stand, and *P. nobilis* remain a synonym of *P. columbina*.

Localities. — Stewart Island, Akatore (Otago), near Dunedin (various localities), near Christchurch (various localities), Gore Bay, doubtless common wherever *D'Urvillea* occurs as far North as Gore Bay. Found only in summer and autumn, a transient species.

Erythrocladia (?)-Porphyra, A Case of antagonistic commensalism.

Rosenvinge (1909) p. 71 established a new genus of parasitic Bangiales under the name *Erythrocladia* and described two species, *E. irregularis* and *E. subintegra*, found in plants of *Polysiphonia urceolata*. Rosenvinge's description of the genus is as follows:—

Thallus horizontaliter expansus, e filis ramosis, aliis algis adfixis radiatim egregientibus, initio inter se discretis deinde in discum tenuem unistratosum confluentibus constans. Crescentia filorum apicalis. Sporangia eodem modo ac in genere *Erythrotrichia* in cellulis intercalaribus vel rarius terminalibus gignuntur. Generatio sexualis adhuc ignota.

Now there is growing in and with a common species of New Zealand *Porphyra* a plant which presents most, if not all, of the characteristics of this genus, and which for the present at least may be placed in it. When the sexual forms of the European species of *Erythrocladia* are discovered, it may of course be found that the New Zealand and European plants are quite different. I propose to call the *Porphyra* associated with it in New Zealand *P. umbilicalis* var *Novae Zeálandiae*, as though approaching such forms as *P. laciniata*, and *P. perforata* of the Northern Hemisphere it appears to be sufficiently distinct; and it is certainly much safer in such doubtful cases as past experience has abundantly shown to regard the local form as different. The *Erythrocladia* I propose to name *E. insignis*. In certain of its forms it is similar in construction to *E. irregularis* of Rosenvinge, but displays a much wider range of structure than the latter, so far as at present known. The following is a condensed description of *E. irregularis* as given by Rosenvinge. The plant forms irregular spots of up to 100 mmm. in diameter on the surface of the host plant. It consists at first of branched filaments whose branches are mutually entirely separate. The primary filament grows out in two opposite directions, and gives off branches at both sides. These branches grow out and branch further, and in the more developed plant the filaments are therefore radiating in all directions in the horizontal plane, and the filaments are then more or less fused together in the central part of the frond. The filaments show apical growth, and transverse walls appear only in the terminal cells. The branches usually arise in the sub-terminal cells, sometimes also in cells nearer the centre of the frond, but the terminal cell is only very seldom ramified. The sporangia are cut off in the ordinary vegetative cells, in a similar manner as in the genus *Erythrotrichia*, by a more or less oblique curved wall (Rosenvinge 1909, p. 72 and 73). Now a description of the New Zealand compound plant will enable a comparison to be made. Plants were collected in all stages at Timaru on August 21st, 1927. The smallest consisted of discs 3 mm.—5 mm.

Photo C M Gray

FIG 1 —*Porphyra columbina* Mont Young linear forms
FIG 2 —*Porphyra columbina* Mont Intermediate circular stage

Photo C M Gray

Fig 3—*Porphyra columbina* Mont Small portion of old plant, from Heathcote Estuary

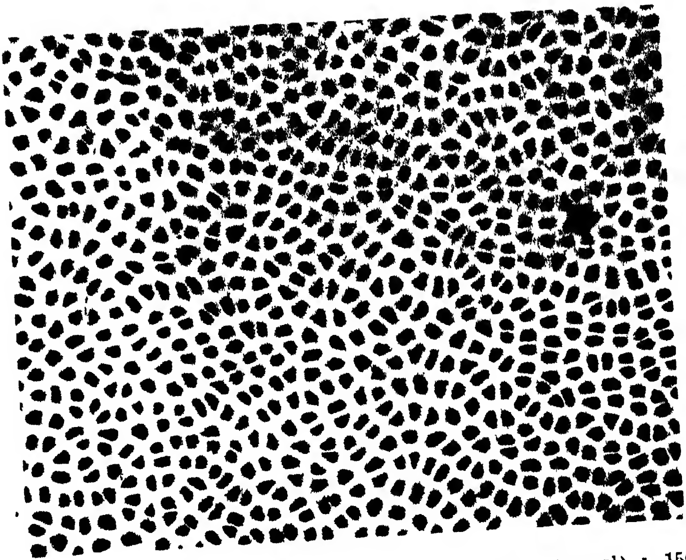


FIG 4 *Porphyra columbina* Vegetative structure (typical) x 150

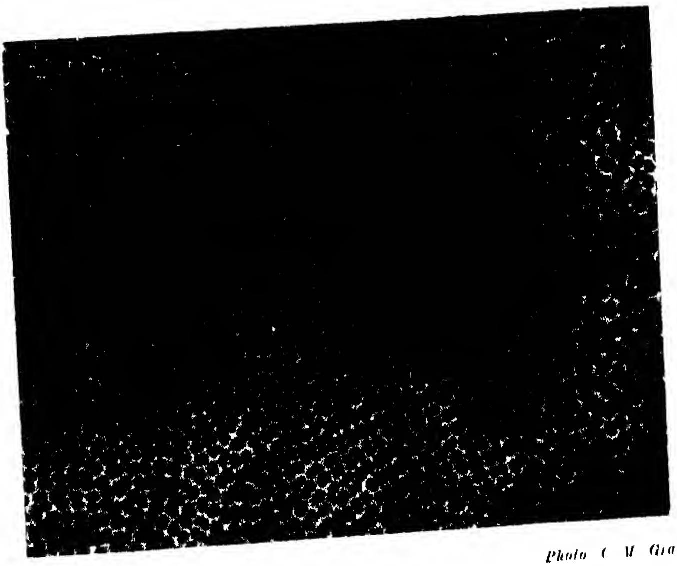


Photo C M Gray

FIG 5—*Porphyra columbina* Antheridia x 150

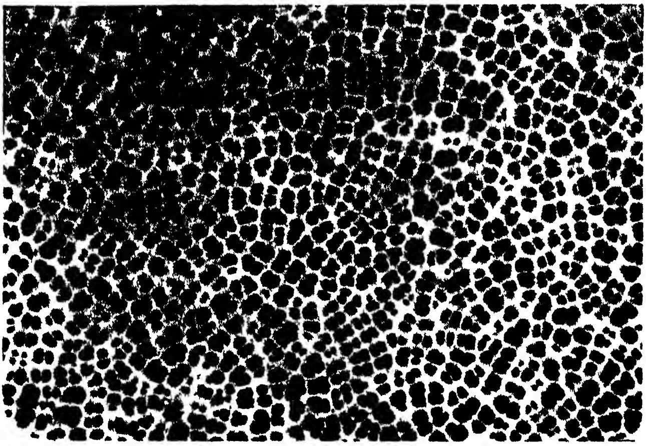
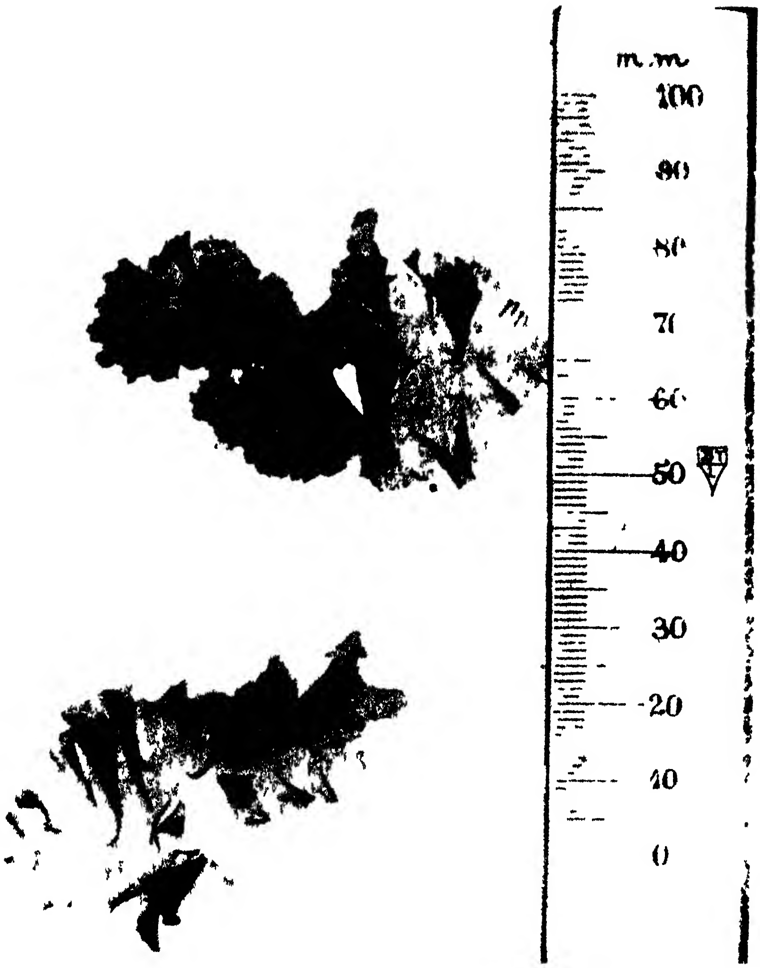


FIG. 6.—*Porphyra columbina.* Young cystocarps x 75.

Photo, C. M. Gray

FIG. 7.—*Porphyra columbina.* Mature cystocarps x 150.



Photo, C M Gray

Fig 8—*Porphyra subtumens* mature plants

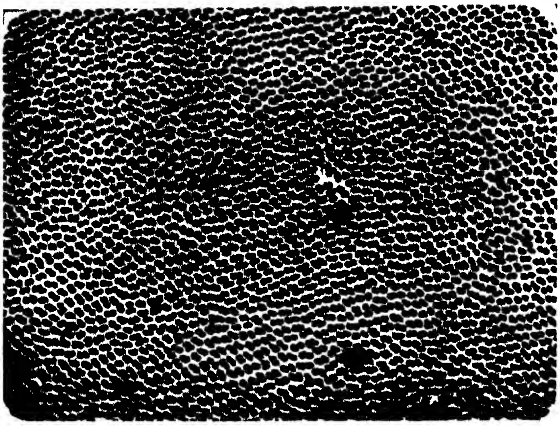


Fig. 9.—*Porphyra subtumens*. Vegetative structure (typical) x 75.

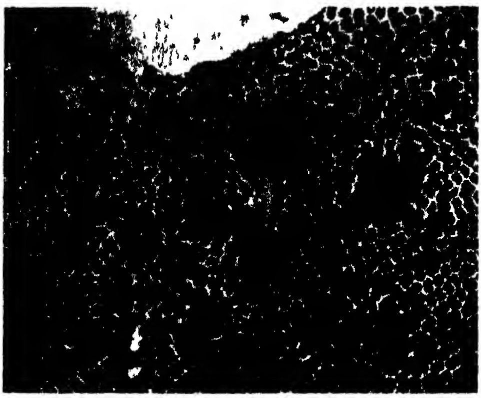


Fig. 10.—*Porphyra subtumens*. Antheridial area (x 125). The deliquescent nature of the thallus is obvious in the slide.

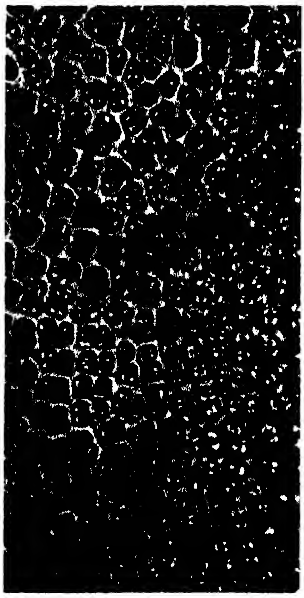


Fig. 11.—*Porphyra subtumens* Cystocarps (x 300).

Photo, C. M. Gray.

Photo, C M Gray

FIG. 12—*Porphyra umbilicalis* with *Erythrocladia insignis*. Portion of broad form, Timaru, September 1927.

Photo, C M Gray

FIG. 13.—*Porphyra umbilicalis* with *Erythrocladia insignis*. Laciniate form, Timaru, August, 1925.

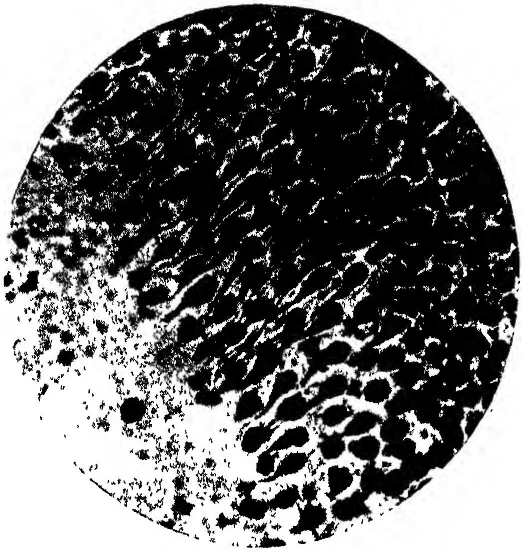
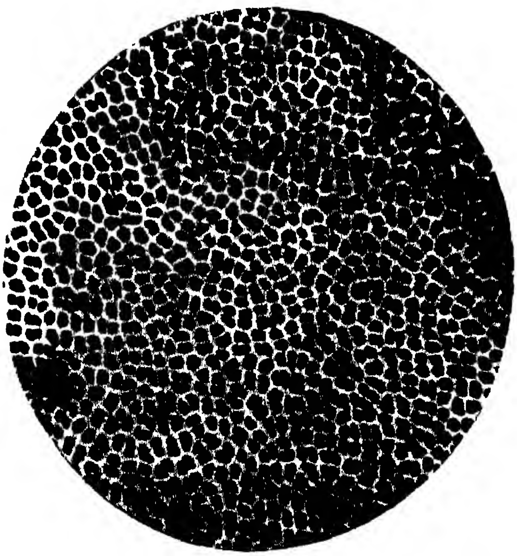


Fig. 14.—*Porphyra umbilicalis*, var. *Novae Zelandiae*. Rhizines at the base, x 140.



Photo, C. M. Gray.

Fig. 15.—*Porphyra umbilicalis* var. *Novae Zelandiae*. Typical vegetative portion, with much gelatine, x 100.

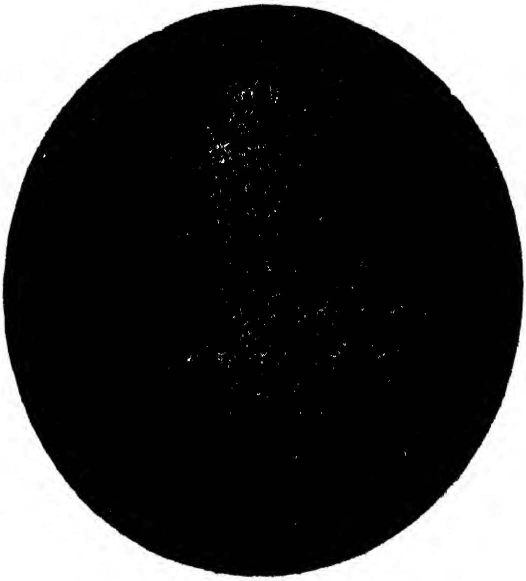
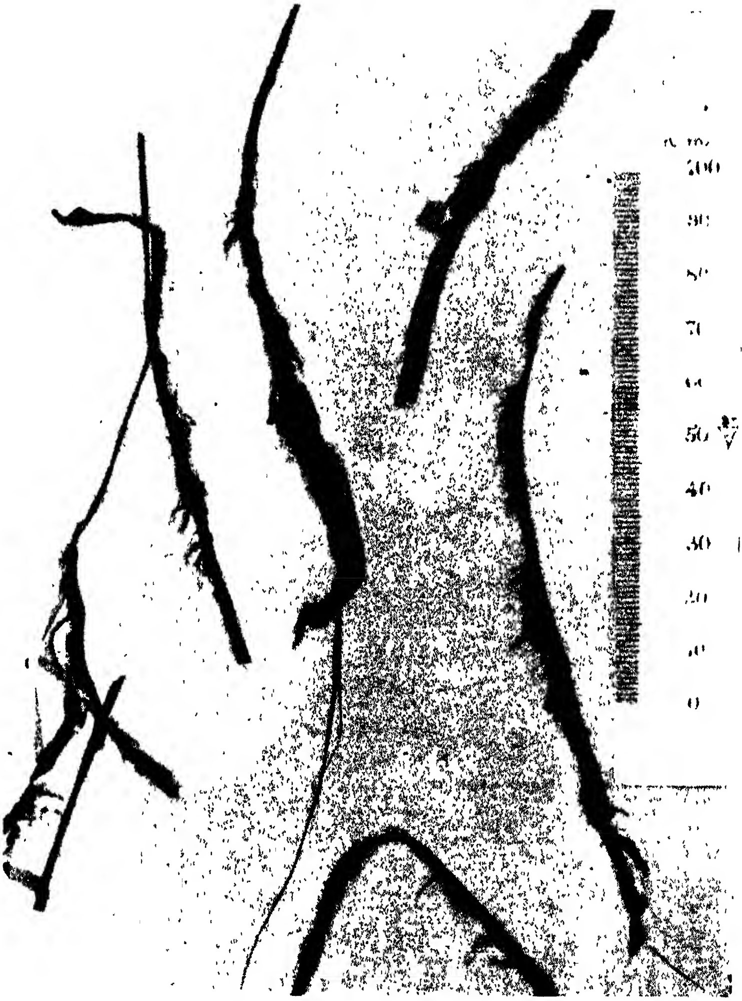


Fig. 16.—*Porphyra umbilicalis* var. *Novae Zelandiae*. Older vegetative portion with little gelatine, x 120.

Photo, C. M. Gray.

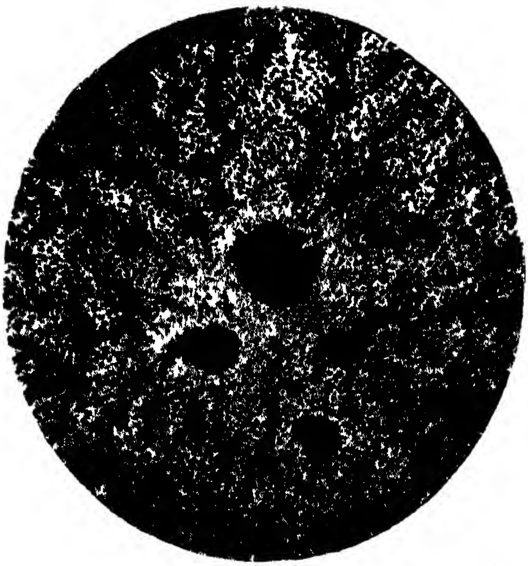
Fig. 17.—*Porphyra umbilicalis* var. *Novae Zelandiae*. Mature cystocarps, x 200.



Photo, C. M. Gray.

FIG. 18.—*Erythrotrichia ciliaris* (?) on Zostera sp.

Fig. 19.—*Erythrocladia insignis.* Invagination. A lense will shew invagination going on in the area surrounded by the arborescences, × 75.



Photo, C. M. Gray.

Fig. 20.—*Erythrocladia insignis.* Cell clusters, surrounded by arborescences, × 75.

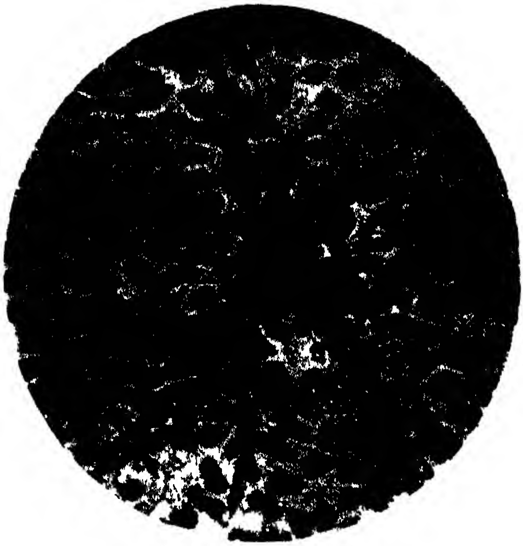
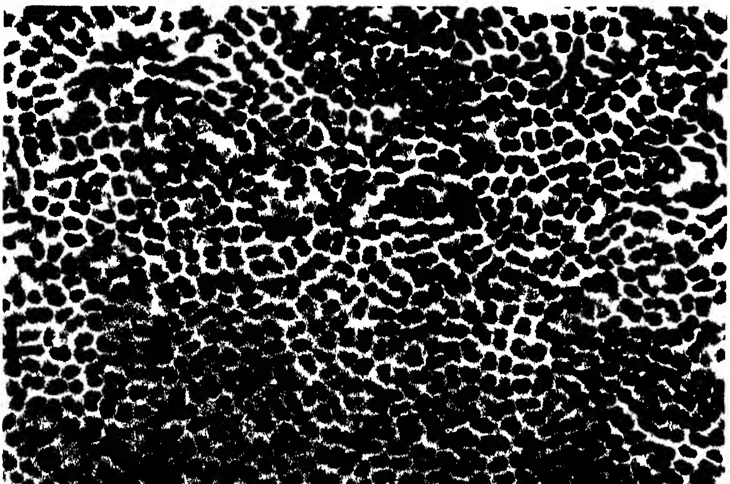


FIG. 21.—*Erythrocladia insignis.* An arborescence, × 200.



Photo, C. M. Gray.

FIG. 22.—Cells of *Erythrocladia insignis* streaming into an area, already occupied by *Porphyra.* The smaller darker cells are those of *Erythrocladia*, the larger paler ones are those of *P. umbilicalis*, var. *Novae Zelandiae*, × 150.

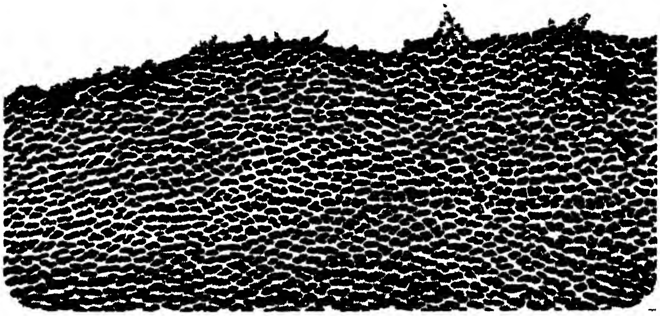
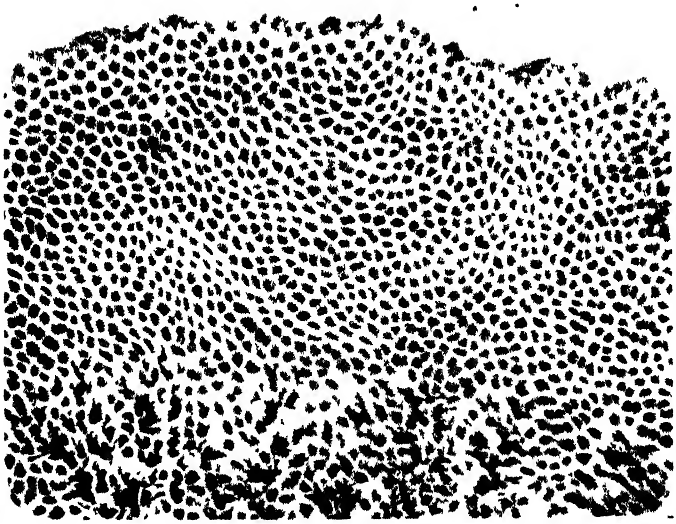


Fig. 23.—*Erythrocladia-Porphyra*, spinulose margin, × 75.



Photo, C. M. Gray.

Fig. 24.—*Erythrocladia-Porphyra*, erose margin, × 100.

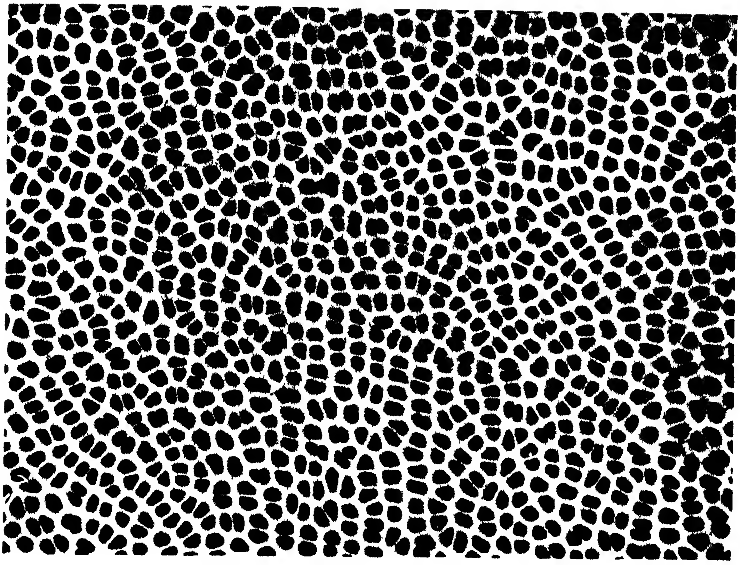
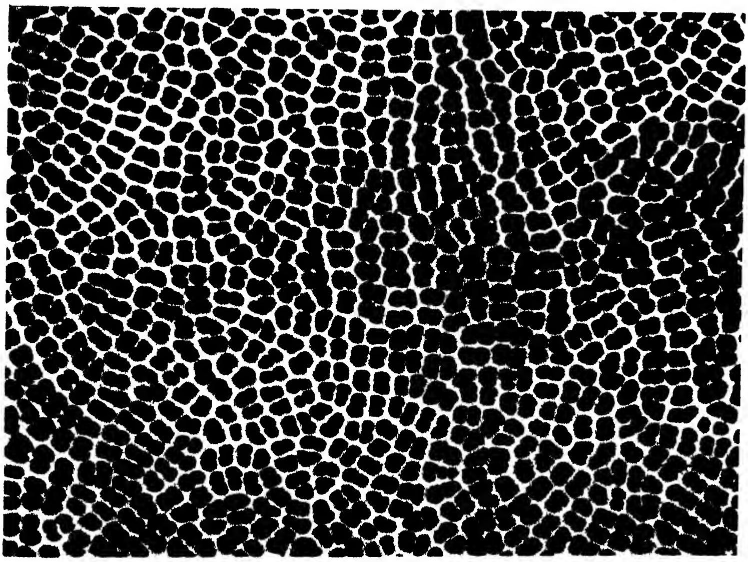


FIG. 25.—*Erythrocladia insignis*. Typical portion of the thallus, without invaginations (x 125).



Photo, C. M. Gray

FIG. 26.—*Erythrocladia insignis*. Cystocarps (?) (x 150).

across, the longest measured was over a metre in length. A description of one of the smallest plants will probably render what follows more intelligible. It formed a small dark-brown thallus some six mm. across. When found it was growing in a crevice in a boulder of doleritic rock on the north mole at Timaru near high-water mark. It was mounted fresh in sea water and examined. The thallus was approximately reniform with a deep sinus at the base, and consisted of two distinct types of cells, those of the *Porphyra* a pale yellow-brown, almost tan-coloured, and those of the presumed *Erythrocladia* dark purple found in minute perforations in the thallus and also in the substance of the frond, sometimes solitary, or at the extreme base mingled in large numbers with those of the *Porphyra.* It may of course be argued that the purple and the brown cells represent different phases in the growth of the cell in one species.

I shall discuss this possibility briefly and give the arguments *pro* and *con.* In favour of this hypothesis are the following facts: (1) In *P. columbina*, as we have already seen (p. 41), there is often an abrupt transition in colour from one portion of the thallus to another without however any difference in form, structure, or size of the cells. (2) Even in the plant we are describing such colour-changes occur, without any other apparent specific differences, or often with slight differences only (a). Thus I have observed similar colour-changes appear in the cystocarps, adjacent groups being tan and dull purple, but as I could trace no difference in construction, I concluded that all the cystocarps belonged to one plant and to one species, and (b) the brown cells undoubtedly do turn purple with drying, and also under other conditions, and (c) in other parts of the frond there are abrupt colour-transitions with only small changes in the size of the cells and the amount of gelatine surrounding them, though here we have probably to do only with cells of the same species in different stages of growth. These facts might seem to show that we are dealing with a single species, which chameleon-like changes its colours with its habits. Obviously colour-contrasts without differences in structure are here valueless for taxonomic purposes.

But, on the other hand, in other parts of the plant we find the same colour-changes correlated with such wide differences in structure, form and size, that we can no longer regard the different groups of cells as belonging to the same species, and here the colour seems to be of taxonomic value. Assuming, for the sake of convenient description, that the purple cells as a rule belong to *Erythrocladia* and the brown ones to *Porphyra,* the following differences are seen to be correlated with the colour: (1) The *Erythrocladia* cells are much more rounded, and girt by wider interspaces of gelatine than those of the *Porphyra.* Often the differences in form are very marked. The cells of the *Porphyra* are usually irregularly rectangular (Figs. 15, 16) 20 mmm.—30 mmm. in length and fit closely together with very little mucilage. Those of the *Erythrocladia,* as seen from above, are usually rather smaller in size, oval or with rounded angles, but sometimes owing to compression they become very irregular in shape, and then they may become triangular, pyriform or even crescent shaped (Fig. 25). Solitary intrusive cells of the *Erythrocladia,* often much narrower and linear, are frequently to be seen wedged in between the

cells of the *Porphyra,* and strewn through the thallus (Fig. 22). (2) The strange invagination process and the accompanying developments never take place amongst the brown cells. At times one of the processes, however, may penetrate a brown cell, or in some way a brown cell comes under the influence of a neighbouring group of purple cells; it then changes colour through pink to purple, and behaves to all intents and purposes as one of the *Erythrocladia* group. Commonly, however, invagination takes place only between purple and purple, and not between brown and brown. It is therefore to be regarded as a structure belonging to the *Erythrocladia* and not to *Porphyra.* (3) The purple cells are usually associated with a spinulose margin, and the *Porphyra* with an erose or entire margin. (4) There may be seen cut off from purple cells, others which have all the appearance of gonidia as described by Rosenvinge for *Erythrocladia.* (5) Associated with the *Porphyra* type of cells are cystocarps, antheridia and gonidia which appear to correspond exactly with those described for *Porphyra umbilicalis.* (6) If it be argued that the purple and brown cells represent different stages in one species, the purple being the younger and therefore the smaller, one would expect in such a case to find cells in transition between the two groups: but these are not to be found. No purple cells so far as I have observed ever turn brown, but brown cells, under the influence of a purple group may be seen changing colour, there it appears to be not a normal but an abnormal change. (7) The process of invasion of the *Porphyra* area by the *Erythrocladia* can often be clearly followed. Streams of *Erythrocladia* cells penetrate the area occupied by the typical cells of *Porphyra,* surround them, and form a network about them The *Porphyra* cells turn pink and apparently shortly disappear (Fig. 22). In this case there is no invagination, the invaginating cells usually being found in open areas in the *Porphyra* thallus, or in areas already taken possession of by the *Erythrocladia.*

Taking all these facts into consideration, I am at present of the opinion that we have here to do with a case of antagonistic commensalism, in which an *Erythrocladia* is closely united with a *Porphyra.*

It is true that as long as I was working with dried specimens, I hesitated to come to this conclusion; but it was the examination of fresh specimens with their remarkable colour-contrasts that led me to arrive at it; and it is on the assumption that the purple cells are those of *Erythrocladia,* unless otherwise indicated, and the brown cells in fresh specimens are always those of *Porphyra,* that I now proceed with the description of the specimens obtained at Timaru. Doubtless this conclusion may not always be accurate, for as we have already seen the cells of *P. umbilicalis* var. *Novae Zelandiae* sometimes are red, but in the main it is a sufficient guide for the description now to be given.

In the small specimen described there were already scores of isolated cells of *Erthyrocladia,* and at least a dozen patches with 10 —20 or more cells, and in addition a large patch round the sinus at the base emitting rhizines similar to those of the *Porphyra* (Fig. 14). Indeed, the attachment disc consisted rather of *Erythrocladia* than of *Porphyra.* I do not know which constituted the original plant;

but as the *Erythrocladia* is elsewhere known as a parasite or epiphyte, it seems better to speak here as if we were dealing with a case of invasion of the *Porphyra* by the *Erythrocladia,* and to regard the thallus as the product of a conjunctive or antagonistic symbiosis; for certainly the *Erythrocladia* seems to displace the *Porphyra*. At the base the *Porphyra* cells are larger than elsewhere, and often contain when fresh a green colouring matter (? chlorophyll undisguised) and as usual a large white pyrenoid (Fig. 14). The *Erythrocladia* has its usual cells of dark purple. The *Porphyra* cells are here 15 mmm.—30 mmm. long, provided with rhizines, and are separated from the adjacent cells by gelatine 1.5 mmm.—2.5 mmm. in breadth. The average breadth of the cells is 10 mmm.—25 mmm. The cells of the parasite are 10 mmm.—25 mmm. in length, and 10 mmm.—15 mmm. in breadth. (A note should perhaps be inserted, that these are the dimensions as measured in fresh specimens mounted in sea-water. These seem to me to be the only correct dimensions. If mounted in a medium containing glycerine, the jelly in particular becomes much swollen, and the cell-dimensions somewhat increased. If passed through alcohol and xylol mixtures as for sectioning, the dimensions, particularly that of the jelly, are much reduced. Consequently, in this paper the dimensions given are always where possible those of the fresh specimens mounted in sea-water.)

The margin of the *Erythrocladia* is irregularly microscopically spinulose (Fig. 23); and the terminal cell in a spinule is triangular. The margin of the *Porphyra* is either completely entire, or slightly erose and irregularly bitten with minute rounded lobes owing to the action of weather and waves (Fig. 24). I have found it with the cells adjacent exactly match a specimen of *P. umbilicalis* var. *laciniata* collected in Halifax Harbour, Nova Scotia, by the well-known American algologist Marshall A. Howe. Indeed, I could find no point of distinction between them; but in our specimens cells of either *Porphyra* or *Erthyrocladia* may be found in either type of margin; nor does it appear to be necessarily the case in such examples that when the *Porphyra* occurs with a spinulose margin, it has always displaced *Erythrocladia,* or when *Erythrocladia* appears with an entire margin, it has necessarily displaced *Porphyra* as might be assumed to be the case. Nevertheless the *Porphyra* type of cell is usually associated with the entire or erose margin, and the *Erythrocladia* with the spinulose margin; and the replacement of one form by the other obviously must frequently take place; thus we may find an invading oval cell in the spinule, which has replaced the normal triangular one. A further distinction between the cells of the two species is that the amount of gelatine round the *Erythrocladia* cells is greater than that round the *Porphyra*, and, in the case of the former, swells much more in glycerine than in the case of the latter.

Taking the colour in the fresh specimen as a guide, we find that the relative amount of each species varies much in the compound frond. Thus one specimen, irregularly oblong and much laciniate, contains only a few basal *Porphyra* cells with rhizines, and one or two narrow patches of *Porphyra* a cm. or two in length, in the upper third of the frond; another plant 35 cm. long much laciniated contains through its centre, and for about a third of its width, a strip

of *Porphyra* which rarely reaches the margin. A third plant of the same length is about 20 cm. wide without laciniations broadly oval in outline, and appears to contain only microscopic amounts of *Erythrocladia* in the form of arborescences (to be defined later). In a fourth plant much laciniated of about the same length as the two previous, I have found only a few cells of *Erythrocladia* amongst the large rhizine-bearing green cells at the base, and I am not sure of the identity of these.

In dried plants of uniform colour it is generally possible to distinguish the two areas by the amount of glaze on the surface. The *Porphyra* is highly glazed, and the *Erythrocladia* dull or only slightly glazed. The reproductive portion of the *Porphyra*, however, is less highly glazed than the vegetative portion, so that this distinction can here only be applied in conjunction with microscopic tests. The greater amount of irregularity in the cells of the *Erythrocladia* is, then, usually sufficient to identify them; but a number of remarkable structures it displays will be described in more detail when we come to consider the species.

I conclude, therefore, that we have here to do with a thallus compounded of *Porphyra umbilicalis* (forma), and what is perhaps an asexual and sexual form of a species of *Erythrocladia.* I am by no means sure that my interpretation is correct; but at present I cannot put forward a better one. In addition to the one given the following have been considered and rejected.

. (1.) That the thallus is a remarkable new species of *Porphyra* compounded of sexual and asexual plants.

(2.) That the thallus contains only a sexual form of *Porphyra* and asexual form of an *Erythrocladia*; but this was held only while some of the facts now disclosed were still unknown, and I do not at present think that it is worth further consideration.

(3.) That the plant is a *Porphyra,* with structures due to disease.

Now I do not propose at this stage to discuss the various points of view further; but if they are borne in mind during the reading of the subsequent detailed descriptions, readers will I hope be able, by the aid of the microphotographs, to form their own opinions on the matter. The theory adopted does not perhaps solve all the difficulties; the weakness lies in the fact that I am not quite certain that I have isolated the sexual form of the *Erythrocladia.* If what I take to be the cystocarps of the *Erythrocladia* are really the gonidia of *Porphyra,* then my theory falls to the ground; but in the absence of further literature it is difficult to decide this question. However, the general identity of the *Porphyra* with the Northern *P. umbilicalis* can scarcely be doubted. Occasionally what appear to be pure specimens of *P. umbilicalis* are to be found. These when dried for a year or two turn to an old-rose-colour, and are glazed. They sometimes display the form of the common *P. vulgaris,* and are much brighter in colour than is the thallus of the mixed species and much glossier. The laciniate forms almost invariably contain both genera.

Porphyra umbilicalis J. Ag. var. **Novae Zelandiae** Lg. var. nov.

Synonymy for the New Zealand forms—

P. laciniata Ag.; Harvey (1855) ii, p. 264.

P. perforata J. Ag.; Lg. 1909, p. 503.

P. perforata J. Ag.. f. *lanceolata* Setchell and Hus.; Lg. 1926, p. 145, No. 147.

P. umbilicalis (L) J. Ag. var. *Novae Zelandiae* in thallo unacum *Erythrocladia insigni* existens, margine undulata et minutissime spinulosa aut laevi erosaque. Frons monoica, antheridiis marginem (2 mm.—3 mm. latis) occupantibus, sporocarpia sine cellulis vegetativis in area sporocarpica, et frequenter antheridiis inmixta.

This variety has now to be separated from *P. perforata* J. Ag. (1882), p. 69; and more fully described by Hus (1902), p. 202; and from *P. umbilicalis* var. *laciniata.* When dried it is indeed very difficult to distinguish them from either of the above without microscopic examination. The spinulose margin, the cystocarpic areas sometimes densely packed to the exclusion of vegetative cells, the frequent presence of antheridial patches in the cystocarpic areas and of cystocarps in the antheridial area, are points of distinction that separate it from both of the preceding, and will be sufficient to distinguish it as a variety from *P. umbilicalis* var. *laciniata.*

It may be further distinguished from *P. perforata.* According to J. Agardh *P. perforata* is distromatic; but Setchell and Hus have shown that this is not so. Further, the figure given by them (Hus, 1902, p. 236, fig. 4a) shows a markedly different thallus from that seen in our plant, where the amount of jelly even in glycerine mounted specimens is not more than $\frac{1}{4}$—$\frac{1}{3}$ the width of the endochrome, and is often less. Hence the name of *P. perforata* hitherto used by myself for this species will have to be rejected.

However, the most important characteristic of var. *Novae-Zelandiae* is the usual association with it in the same thallus of plants of *Erythrocladia insignis.*

Forms of Thallus and Colour. — The young plant has already been described under *Porphyra-Erythrocladia.* From it there is usually developed a long narrow linear strip, though other forms may sometimes be seen. Thus a number of young specimens obtained at Taylors Mistake (near Christchurch) in July were 10 cm.—13 cm. long and only 5 mm.—10 mm. broad; but as the plant grows the relative breadth increases and several fronds may grow up from one base. (Fig. 12.) At Timaru, in September, specimens up to a metre in length could be obtained, with a width of 20 cm. or more. These larger specimens are usually irregularly laciniate, proliferous from the margin (Fig. 13). There is no uniformity in the shape of the mature plant, but it can usually be distinguished by its greater length and more divided thallus from *P. columbina*; and it has, as it lies on the rocks, more of a brown-red tinge in the thallus when viewed by reflected light, where *P. columbina* similarly viewed displays a certain amount of olive-green. However, the redder colour of *P. umbilicalis* var. *Novae Zelandiae* is no doubt due in large measure to the presence in it of *Erythrocladia insignis.*

Both species after a hot, dry summer disappear, and between December and June *P. umbilicalis* var. *Novae Zealandiae* sometimes cannot be found in its usual habitats. It is an annual, but reaches maturity in six weeks or two months after its first appearance, and so there may be several generations in the course of a year; but on this point I have no definite information. On drying, the plant passes through an almost indefinable series of shades—amber, burnt sienna, brown-purple to plum-colour. It does not show the lilac tinge of *P. columbina,* and remains a brighter and redder colour in the herbarium. The antheridial areas are colourless, and the cystocarpic portions much redder than the vegetative.

Minute Structure.—The plant is monostromatic 75 mmm.—100 mmm. in thickness in a glycerine mount with cells usually oblong in section up to 25 mmm.—30 mmm. in length, somewhat irregular in outline, and 15 mmm.—20 mmm. in breadth. The rest of the thickness is made up of jelly. The relative amount of jelly in fresh specimens is probably considerably less; but as fresh materials cannot be sectioned, it is not possible to give accurate measurements in this respect.

The cells vary considerably in height, and though usually fairly regularly oblong with rounded corners are sometimes twice as deep as broad, and sometimes nearly as broad as deep, but they are on the average not nearly so square as those of *Erythrocladia,* and not so irregular. A portion from the centre of the frond, mounted fresh in sea-water and viewed from above shows cells of a dull-yellow to amber-brown in close contact with each other, practically without visible mucilage, irregularly rectangular to oval in shape, sometimes 5-6 sided, length 15 mmm.—25 mmm., breadth about half the length (Fig. 16). Towards the base the frond becomes greenish, and the cells more oval and larger, and there is more gelatine. For dimensions of basal cells, see p. 49. Towards the margin the cells are similar to those in the centre of the frond, but tend to elongate somewhat and to arrange themselves in lines parallel to the edge of the frond.

Reproduction.—The cystocarps are densely packed together across the surface of the frond, and usually without vegetative cells. Enclaves of antheridia are sometimes to be found in the cystocarpic area; but usually the antheridia are to be found along the margin as in other species. In fresh materials the cystocarps are brown or pink 20 mmm.—30 mmm. in length, and 15 mmm.—20 mmm. broad, and of the same colour as the vegetative cells, and therefore not readily to be distinguished without microscopic examination. In this respect they are markedly distinct from those of *P. columbina.* Amongst them may occasionally be found large pale-yellow cells which are possibly dead or undivided cystocarps. As the plant becomes mature the cystocarps are so appressed together as to become almost indistinguishable. In younger areas there are many undivided carpogonia. The usual number of divisions is 4, but occasionally 8 may be found; and with 2 tiers in depth this gives the ordinary number of carpospores as 8; but they may I think be occasionally 16 (Fig. 17). There are occasional groups of cystocarps

in the antheridial area. The thallus does not show thickening here as in *P. columbina*, and is usually about 75 mmm. deep in a glycerine mount, the cystocarps being 30 mmm.—35 mmm. in height. It is not uncommon to find among the cystocarps, a solitary arborescence of *Erythrocladia* (v.p. 57) or even solitary cells of the same plant.

The antheridial area is typically marginal 2 mm.—3 mm. wide, entire and not spinulose. The antheridia which are colourless are somewhat smaller than the cystocarps 15 mmm.—20 mmm. long, and about the same in width, being more nearly square than the former, which are approximately rectangular. As seen from the surface, the antheridium divides in 4, occasionally into 8, and rarely into 16 surface divisions. In section two, 4 or even 8 tiers are seen. The common number of spermatia is 32; there may be 64, or rarely 128. No vegetative cells are to be seen among the antheridia, but there are occasionally to be met with large nearly colourless solitary cells, oval or circular, whose significance is unknown to me.

Localities.—Dunedin (Black Head, St. Clair Tomahawk, etc., W. A. Scarfe!), Timaru, Christchurch (Governors Bay), Purau, Sumner, Gore Bay, Wellington (Mahanga Bay, Lyall Bay). Doubtless it is common along the coast, though not yet identified. My best specimens come from Timaru. Apparently it largely disappears in the winter months.

ERYTHROTRICHIACEAE.

Gonidia arising in special monosporangia, cut off by a curved wall in a vegetative cell.

Erythrotrichia: Frond erect filiform.

Erythrocladia: Frond consisting of creeping branched filaments, more or less confluent to a monostromatic disc.

Erythrotrichia ciliaris (?) (Carm.) Batters.

The following description is quoted from de Toni (1924), p. 15:

Erythrotrichia ciliaris (Carm.) Batt. in Journal of Botany, 1900, p 374. Frondibus obscure purpureis, 500—800 mmm. longis, 10—30 mmm. latis (in speciminibus aliis 1—2 mm. longis, 10—200 mmm. latis), numerosis a disco monostromatico exsurgentibus, disco 20 mmm. rotundato, 50—200 mmm. diam. aequante, cellulis rotundatis polygoniis, 15—24 mmm. diam. aequantibus; sporis circ. 18 mmm. diam. metientibus.

Now *Erythrotrichia ciliaris* is a little known and not well-understood species, recorded by de Toni only from Great Britain. It has been confused with *E. Bertholdii* and other species, and it seems most unlikely that it should be found in Great Britain and New Zealand and not in intervening districts. However, there are one or two casual notices of it elsewhere. Reinbold, *Deutsche Sudpolar Expedition* (1901-03) doubtfully records it from New Amsterdam; and states that it is known from the coast of Europe, The Cape of Good Hope, Australia, and Martinique. A. and E. S. Gepp (*Journal of Botany,* Dec. 1905) "Some cryptograms from Christmas Island" (Indian Ocean) also list it. But some of these localities are undoubtedly questionable. Hook and Harv., 1867, p. 716 record it from Cook Strait, "parasitic on leaves of Zostera, Lyall," under the following description.

"*Bangia ciliaris.*—Filaments minute, simple, straight, ½in. long, variable in breadth, compressed, purple, sometimes expanding and leafy in the middle; cells in 2 rows except, where expanded, globular." I also found what is perhaps the same plant growing on leaves of *Zostera* in Akaroa Harbour, June 2nd, 1904; and on sending specimens to Major Reinbold he returned it as *Bangia ciliaris,* hence the plant appears in my list (1926), p. 146, No. 144.

Further examination shows the species arising from a disc closely adherent to the *Zostera.* Now the genus is divided into two sections, according to the absence or presence of a disc. This brings our plant into the group possessing a disc with *E. Boryana, E. ciliaris, E. polymorpha,* and several other species. At present I have only dried specimens to work with, and cannot define the species sufficiently to identify it with certainty. Harvey's description, however, appears to be correct so far as it goes. The filaments which in the first stage consist of a single row of cells, expand and become "leafy" in the middle. This seems to suggest *E. Boryana* rather than *E. ciliaris. E. Boryana* is a more widely distributed species than *E. ciliaris,* being found in the Mediterranean as well as in the North Atlantic. However, it is most probable that on further examination our species will be found to be new. I have not seen the monospores. The plant grows up to 10 mm. in length and may be 1—2 mm.wide. The cells vary in relative length and breadth, sometimes broader than long, or again longer than broad. They may measure as much as 20 mmm. in length or breadth, but are usually smaller, and be as small as 5—10 mmm. in length and breadth. The cells can scarcely be called globular; but are more often rectangular. Our plant, judging from the description in de Toni, seems to be larger than the true *E. ciliaris,* and than most of the species described. (Fig. 18.)

Erythrocladia (?) **insignis,** Lg. sp. nov.

Erythrocladia (?) species in *Porphyra laciniata* var. *Novae Zelandiae,* et in *Porphyra columbina* habitans. Thallus primo singularium cellularum stratum monstrans deinde cellulae inter se invaginantes discum crassum monostromaticum formantes filis ramosis radiatim egredientibus aut inter se discretis sine disco. Gonidia eodem modo ac in genere Erythrotrichia in cellulis intercalaribus gignuntur, generatio sexualis Porphyrae similis.

Minute Structure.—The general characters of the thallus have already been described in dealing with *P. umbilicalis* var. *Novae-Zelandiae,* and do not require further attention here. There are, however, many details of the minute structure which are of much interest, and which must be further described. The first cells of *Erythrocladia* are much less angular and much more oval in shape than those of the host. They divide similarly into sets of four, but they soon lose their regular shape, as they intrude into the thallus of the *Porphyra* and become most irregular in form, becoming linear, angular, pyriform, and indeed too varied for general description. They average perhaps 10 mmm.—25 mmm. long and 10 mmm.—15 mmm. in breadth, but may be much larger or smaller. They are approximately square to rectangular in section, but often quite

irregular and up to 25 mmm. deep, and the total thickness of the thallus is less than that of the *Porphyra*, being only 45 mmm.—55 mmm. The breadth of the gelatine between two adjacent cells in the earlier stages is greater than that in the case of the *Porphyra*, and equal to 5 mmm. The interest in them lies mostly, however, in certain processes and structures they display, which may be termed.

(*a*) invagination
(*b*) cell clustering, and
(*c*) arborescence.

(*a*) *Invagination* may be seen in a plant of a few mm. in length. Many of the cells become incurved at the base, and the opposed cell-wall of the adjacent cell becomes convex. Then the convex cell puts out one, two, three or even four rhizine-like processes. These processes may divide di- or even tri-chotomously, and then penetrate the wall of a neighbouring cell; or a concave and convex cell may become appressed and unite, with disappearance of the intervening cell-wall. In this way, cells may be linked together in any part of the thallus where *Erythrocladia* occurs. Frequently the invaginating cells may be found in a circle, from which they radiate out in all directions (Fig. 19).

(*b*) *Cell clustering.*—Frequently a group of cells orient themselves round a central cell, link up with it and form a central disc 300 mmm. and upwards in diameter with threads of linked up cells, branching out from it in all directions (Fig. 20).

(*c*) *Arborescence.*—A single cell may send out from one end two three or even four processes, and so link itself up with several other cells, these in turn invaginating with neighbouring cells form a branched tree-like growth 300 mmm.—500 mmm. or more in length. Such a growth may be termed an *arborescence* (Fig. 21). I have never seen a cell emitting processes otherwise than from one end, but there is immense variety in the structures that may be formed. In some cases one may have discs or cell-clusters formed without arborescence. These clusters may often be found running roughly parallel with each other in any part of the frond. They usually contain 10—12 cells, more or less completely amalgamated and forming a little richly-coloured tubercular mass projecting from the frond. In other cases the invaginating cells form circular patches without definite arborescence, producing rather a network, enclosing in many cases larger cells, which are perhaps isolated *Porphyra* cells. Similarly also circular patches of cells may invaginate without showing either arborescence or cell-clustering, or one may have a series of arborescences radiating out from a centre, but not connected with each other or with that centre. This, of course, occurs also in *Erythrocladia subintegra* Rosenvinge, with which our plant seems to be allied. In other cases one may find a large cell-cluster connected up with arborescences, which have subsequently decayed and left the cluster surrounded only by a few isolated cells in the gelatine. The variety of forms assumed is remarkable, and it is impossible to describe them all.

If the colourless process put forth, does not meet another cell, it may often expand into a colourless sphere 3—5 mmm. in diameter,

or assume the shape of a wine-glass. This slowly colours until it has the appearance of a stalked cell.

The description given is for *Erythrocladia* as it occurs in *Porphyra umbilicalis* var. *Novae Zelandiae*. A similar or perhaps the same *Erythrocladia* as already noted occurs in *P. columbina*, but here it seems unable to hold its own. Dead patches of cells, presumably those of *Erythrocladia*, may often be found in perforations in the thallus of *P. columbina*, and though *P. columbina* seems usually to be infected with *Erythrocladia*, particularly at the base, I have not yet found any large patches of *Erythrocladia* in this species.

In the literature available to me, I have been able to find very little comparable to the invagination process and arborescence. The species of *Erythrocladia* described by Rosenvinge have obviously arborescences similar to those of this species; but he makes no mention of invagination. J. Agardh, however (1899), p. 149 *et seq.*, observed a similar though less well-developed case of this latter phenomenon in *Porphyra nerocystis* Anderson; and in consequence of his observations constructed the new genus *Pyropia*, but this genus was not accepted by Hus. (1901), p. 210; nor by Wille or de Toni (1900), p. 18. Why it was rejected by them I do not know. Though Hus refers to J. Agardh's paper in his bibliography, he does not mention it in his text. Agardh describes his plant under the name *Pyropia Californica;* and I extract a short passage from his description loc. cit. p. 151, et p. 152.

Ex singulis cellulis frondis interioribus, adparenter sua propria membrana cinctis, endochroma expansum vidi in appendicem rostratum, et formam ipsius endochromatis modo offerre unam partem obovatam et conspicue crassiorem, alteramque excurrentem in appendicem plus minus rostriformem; adparatum rostriformem expansum vidi (intra membranam frondis exteriorem) supra partem obovatum proximae cellulae; dum eodem modo partem obovatam intrudentis cellulae (adhuc obtusam) vidi conformi appendicula ab alia cellula proxime vicina proveniente depressam. . . . Si unaquaque cellula ex uno apice expanditur in appendiculam, eandem cum alia cellula conjugentem; supra alteram vero suam partem incrassatum recipiat consimilem appendiculam, ab alia cellula emissam, facilius, pateat totam structuram hoc modo arctius in formam frondis definitam contineri.

Now I have neither specimens of *Porphyra nerocystis*, nor of the species of *Erythrocladia* described by Rosenvinge, nor of all the literature necessary, so I cannot pursue this matter further, but it would seem probable that Agardh has found in *Porphyra nereocystis* (*Pyropia*) phenomena similar to those that occur in *Erythrocladia insignis*. Either the *Porphyra* contains a parasitic species, or else his genus *Pyropia* may be found on further investigation to stand, or we must expand our definition of the genus *Porphyra*. It is probable of course that in the case of our New Zealand *Porphyras* one thallus contains many individuals of *Erythrocladia*, but it is at present quite impossible to distinguish between one individual and another.

Reproduction.—In the arborescences occur cells bearing all the appearance of gonidia as described for the genera *Erythrotrichia*,

Erythrocladia and *Porphyroyopsis* by Rosenvinge. These are cut off by a slightly curved cell-wall from the side or end of the cell, or more rarely from solitary cells in the neighbourhood of invaginated areas. It is possibly these gonidia which, scattered throughout the plant, give rise to new individuals in the *Porphyra* thallus.

Sexual Reproduction. — Densely packed cystocarps (?) occur without vegetative cells, towards the edges of the frond, two or three centimetres deep, divided into two and four without any division parallel to the surface of the frond (Fig. 26). Thus the total number of carpospores is only four. Outside these are antheridia divided into four or rarely eight surface dvisions and arranged in four tiers, thus giving sixteen, rarely thirty-two spermatia. The antheridia are colourless, but the red cystocarpic area fades out imperceptibly into the antheridial area. The cystocarps are 10 mmm.—15 mmm. across. The antheridia are 8 mmm.—10 mmm. across and 10 mmm.—12 mmm. in length.

Localities: See *P. umbilicalis* var. *Novae Zelandiae.*

CHIEF REFERENCES TO LITERATURE.

AGARDH, J. G. (1877).—De Algis Novae Zelandiae Marinis (Lunds Univers. *Aarskrift* T. 14) Lund.

—— (1882).—Till Algernes Systematik nya Bidrag iii. 6 Ulvaceae (Lunds Univers. *Aarskrift* T. 19) Lund.

—— (1889).—Analecta Algologica Cont. 5 (*Act. Reg. Soc. Physiogr.* T. 10) Lund.

DE TONI, J. B. e FORTI A. (1923).—*Alghe di Australia, Tasmania e Nuova Zelanda,* Venezia.

DE TONI, J. B. (1924).—*Sylloge Algarum* Vol. 6, Padua.

ENGLER, A., und PRANTL K. (1897).—*Die naturlichen Pflanzenfamilien* Teil 1. Abteilung 2. Leipzig.

HOOKER, J. D. (1844-1847).—*Flora Antarctica* Vols. 1-2 London (The seaweeds are by W. H. Harvey).

—— (1853-1855).—*Florae Novae Zelandiae,* Vols. 1-2. (The seaweeds are by W. H. Harvey)

—— (1867).—*Handbook of the New Zealand Flora.* (The seaweeds are by W. H. Harvey.)

HUS, H. T. A. (1902).—An account of the species of Porphyra found on the Pacific Coast of North America. *Proceedings of the California Academy of Sciences.* Third Series. Botany Vol. 11, No. 6, San Francisco.

LAING, R. M. 1899.—Revised List of New Zealand Seaweeds, Part I. (*Trans. N.Z. Inst.* Vol. 32, pp. 55-70) Wellington.

LAING, R. M. 1902.—Revised List of New Zealand Seaweeds, Part II. (*Trans. N.Z. Inst.*, Vol. 34, pp. 327-359) Wellington.

—— 1926.—A Reference List of New Zealand Marine Algae (*Trans. N.Z. Inst.* Vol. 57, pp. 126-185) Wellington.

LAING, R. M. (1909).—The Marine Algae of the Sub-antarctic Islands of New Zealand, in Chilton, *Sub-antarctic Islands of New Zealand*, Vol. 2, pp. 503-527. Wellington.

LE JOLIS A. (1864).—Liste des algues marines de Cherbourg. *Memoires de la Société impériale des sciences Naurelles de Cherbourg* T. 10. (The Porphyreae in this volume are chiefly described by G. Thuret).

MONTAGNE, C. 1845.—Plantes cellulaires du voyage au Pole sud sur les corvettes l'Astrolabe et la Zelée sous le commandement de M. J. Dumont D'Urville, Paris. (Montagne Prodr. Phyc. Antarct, is not available in New Zealand.)

OLTMANNS, DR. F. (1922).—*Morphologie und Biologie der Algen.* Jena.

ROSENVINGE, L. KOLDERUP (1909).—*The Marine Algae of Denmark*, Part I, Introduction Rhodophyceae. (Bangiales and Nemalionales.)

A Brief Account of the Re-establishment of Vegetation on Tarawera Mountain since the Eruption of 1886.

By E. Phillips Turner, F.R.G.S.

[*Read before the Wellington Philosophical Society, 23rd November, 1927; received by Editor, 19th December, 1927; issued separately, May 12th, 1928.*]

Plates 16—19.

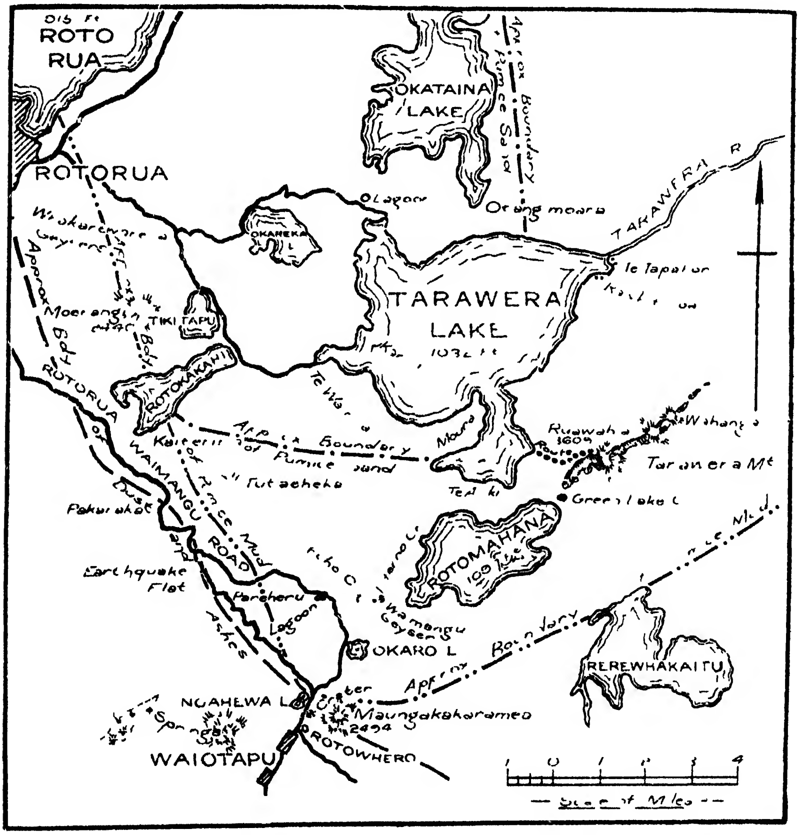
On June 10th, 1886, occurred the Tarawera eruption which destroyed the incomparable and world-famous Pink and White Terraces at Lake Rotomahana, and which scattered volcanic mud or ash over about six thousand square miles of country. I was, at the time, an assistant on the survey of the railway line which now gives access to Rotorua, and during the two days following the eruption I tramped from our camp at Ngatira, via Rotorua and the Blue and Green Lakes, right through to Tarawera Lake. Though in the vicinity of Rotorua township the volcanic deposit was little more than a film, it increased rapidly in thickness, and between the Blue Lake and Lake Tarawera (Fig. 1) the mud was so deep that I sank almost to my hips whilst trudging through it. Previous to the eruption, at several places between Rotorua and Lake Tarawera there had been patches of beautiful forest, but now there was no vestige of live vegetation to be seen, as the whole country was buried under a huge thick sheet of mud out of which a few mud-plastered, blasted tree-trunks alone gave proof of the previous existence of the forest.

In 1889-1900, from 14 to 15 years after the eruption, I was engaged in surveying lands which had been purchased by the Crown from the Maori owners in the vicinity of Rotorua, the Blue Lake, Lake Tarawera, Lake Rotomahana, etc., and I then found that many of the forest trees and large shrubs in this locality had merely been stripped of their small branches and leaves at the time of the eruption, and that they now bore profuse and healthy foliage. Indeed many places where the vegetation had previously been *Pteridium esculentum* or low scrub now bore a completely new growth of *P. esculentum, Coriaria arborea* or *Aristotelia serrata* which were growing on the ejected mud or on scars that had been caused by the ejected mud having slid from the sides of steep hills.

In the year 1900 on the ash and mud-covered lands abutting on to Lake Tarawera (on the West) and in the vicinity of the new Lake Rotomahana and the celebrated Waimangu Geyser there was a considerable pioneer growth of *Arundo conspicua, Coriaria arborea,* and *Pteridium esculentum.* These lands prior to the eruption bore a profuse growth composed mainly of *Leptospermum* scrub and *Pteridium esculentum.* I made the ascent of Mount Tarawera in 1900 and, as far as my memory serves, there was then no new vegetation on the western slopes of the mountain, but I regret that I did not make any notes on the matter at the time.

The first account of the new vegetation on the land covered with the matter ejected at the Tarawera eruption of 1886 was given by L. Cockayne in the 1910 edition of *New Zealand Plants and Their Story* (3 p. 54), but only *Coriaria* and *Arundo* are therein mentioned.

In 1913 and again in 1915 and 1916, B. C. Aston (1, 1a) visited Tarawera Mountain and found its western slopes were carrying a growth of small trees, shrubs, and herbaceous plants, which were abundant near the shores of the Lake, but gradually lessened as the mountain was ascended. In a very interesting account of his



Re-establishment of Vegetation on Tarawera Mountain since the Eruption of 1886.

visits Aston showed that of the ninety-one species of plants he recorded as growing on the north-western flank of Mount Tarawera 58% were plants which had become established there through the agency of wind; 26% had been spread by birds, and fourteen species were difficult to account for.

In January of the present year (1927) I took the opportunity during a short holiday to make a hurried ascent of Mount Tarawera,

which I had not visited since I ascended it in 1900. I was of course immensely impressed with the great changes which had occurred since my first visit, for now near the shore of Lake Tarawera there was a young forest with trees from 7.5 to 12.2 metres high, and above the forest, shrubs and herbaceous plants occupied the ground more or less plentifully right to the summit of the mountain, which at its highest peak is 1149.4 metres above the sea, or 834.7 metres above the mean level of the Lake. The point at which I started my ascent on the present occasion is about midway along the Eastern shore of a large bay at the southern end of Tarawera Lake (vide map), and I followed up a flat-floored steep-walled and narrow valley, which has been eroded since the big eruption of 1886 and extends nearly to the rift-like crater which split the mountain. The soil of the valley—as in other parts of the mountain—is a coarse sand mixed with large quantities of scoria and rock from the size of a pea to blocks many pounds in weight. The origin of the soil has been both rhyolite and andesite, stones and particles of the latter preponderating. In heavy rains a large volume of water descends from the higher slopes, but the soil is so loose and gravelly that probably as much water flows under the surface as above it.

In the lower part of the valley (Figs. 2, 3) the chief components of the scrub growth which intermittently occupies the floor are *Coriaria arborea*, with *Leptospermum scoparium* and *L. ericoides* in lesser quantity. *Raoulia australis* forms numerous mats on the floor, and *Pimelia prostrata* is also present with a similar habit of growth. On the sides of this part of the valley the scrub formation is more varied and contains in addition *Coriaria*, *Aristotelia serrata*, *Nothopanax arboreum*, *Hebe salicifolia* var., *Fuchsia excorticata*, and the two *Leptospermums*. Scrambling over these small trees *Muehlenbeckia australis* is often seen, whilst between them there may be *Pteridium esculentum*.

At an altitude of about 518.3 metres (204.2 metres above Lake Tarawera) the mat-plants *Raoulia australis*, *R. tenuicaulis*, *R. glabra*, and *Pimelia prostrata* occur as scattered colonies on the fine loose scoria or sand. In these colonies there are often other plants, *e.g.*, *Hypochoeris radicata*, *Gaultheria oppositifolia*, *G. rupestris*, *G. antipoda*, the two *Leptospermums*, and *Danthonia semiannularis* var. On gravelly soils or soils composed of coarse sands, as has been elsewhere related by Cockayne (2, 3, 4 and 5) and Aston (1, 1a) these mat-plants, by their action in arresting the movement of the sand particles and also their habit of decaying at the centre of the mat, form suitable spots for the establishment of hardy pioneer plants with an erect habit of growth such as those just named. Near this locality (Fig. 4) there are a few small clumps of Coriaria scrub. One of these was composed of *C. arborea* about 3.5 metres high with two small trees of *Pittosporum tenuifolium* in the middle 6.9 metres high. On these trees the epiphytic fern *Cyclophorus serpens* was growing. Around and under the shade of this clump there was quite a dense carpet-growth of *Danthonia*, *Hypochoeris radicata*, the grass *Holcus lanatus*, *Acaena Sanguisorbae*, *Aira caryophyllae*, *Pteridium esculentum*, *Centaurium umbellatum*, *Epilobium pubens*, *E.* sp., *Raoulia glabra*, *R.*

australis, Lagenophora petiolata, Pimelia prostrata, moss, *Muehlenbeckia axillaris, Microtis uniflora, Polypodium diversifolium,* young pittosporums, *Pomaderris phylicaefolia,* and *Anagallis arvensis.*

Occurring sporadically at this altitude there were also *Gaultheria oppositifolia, G. antipoda, Epilobium melanocaulon,* two *Leptospermums, Pteridium esculentum, Hebe salicifolia* var., *Dracophyllum subulatum, Thelymitra longifolia, Hypochoeris radicata, Trifolium dubium, Celmisia longifolia, Gahnia gahniaeformis, Leucopogon Fraseri, L. fasciculatus, Gaultheria rupestris,* and *Erigeron canadensis.* These plants extend down to the lake, and, in lessening quantity, up the mountain for over 100 metres.

At an altitude of about 853 metres above sea-level the same scattered low shrubs and the same *Raoulias,* grasses, and *Pimelia* are found in lesser number. It is interesting to state that in 1900 (14 years after the eruption) the loose scoria at this altitude was still quite warm at about 12 centimetres under the surface, but on the present occasion it was quite cold.

Looking into the crater-rift at this point (Figs. 5, 6) one could see, perched at various places on its perpendicular walls, shrubs of *Coriaria* and *Gaultheria oppositifolia*—the former probably the result of carriage by birds, the latter by wind.

The walls of the crater at this place were too steep to allow one without ropes to descend to test the temperature of the rock and soil, but I was told that at some places in the crater steam is still emitted.

At an altitude of about 915 metres above sea-level there is a slope of fine scoria lying at an angle of about 33°. Though the scoria here slides downhill when walked upon, there are established on it odd patches of *Raoulia australis,* with an occasional *Gaultheria,* and *Hypochoeris.* On this loose and unstable slope, where the moisture reaches the surface, there are occasional little oasis-like compact colonies composed mainly of *Raoulia glabra,* with some *R. australis,* and a little *Hypochoeris, Trifolium dubium, T. repens,* a minute *Raoulia* (apparently a hybrid between *R. glabra* and *R. australis*), *Pimelia prostrata,* and a minute *Epilobium* which I did not identify.

In connection with this special ability of the *Gaultheria* to colonize unoccupied new lands, I may state that when I was making a topographical survey of the Tongariro National Park, in 1908, I found impressions of *Gaultheria rupestris* leaves to be common in three distinct strata of soil which must have been ejected at various times from one of the volcanoes in that locality when they were in a very active condition long ages ago.

On the summit of the mountain (the southern part, about 1,120 metres, was all I had time to visit) I found an intermittent and sparse vegetation composed of stunted *Gaultheria oppositifolia, G. rupestris,* an apparent hybrid between *G. oppositifolia* and *G. rupestris, Celmisia longifolia* var. *gracilenta, Leptospermum scoparium, Dracophyllum subulatum, Danthonia semiannularis* var., and *Hypochoeris,* all of which have probably been established through the agency of wind. The shrubs appear to have become established here since

Aston's visit. I may mention that snow not infrequently covers the mountain in winter, and it may occasionally lie on the summit for as long as a week or perhaps even more. The rainfall in this locality is between 128 and 154 centimetres (50 and 60 inches), and it is very well distributed, no month being without rain, so the climate favours vegetation. The loose and coarse nature of the soil and its great porosity have already been referred to above.

With respect to the fauna of this part of the mountain it may be said that blackbirds and thrushes and the indigenous tui, all frugivorous birds, were seen or heard on the lower slopes. Two wild horses were seen, and also recent excreta of rabbits and wild pigs. The native pipit was occasionally seen even high up the mountain. Of the animals, rabbits might occasionally carry grass seeds or the pappus-furnished seeds of the composites or the barbed seeds of *Acaena*; but pigs and horses would take a far smaller part in the dispersion of such seeds. All the plants observed by me on and near the summit of the mountain were such as have either very light, small, or pappus-furnished seeds, and this fact confirms the observations of others that wind is definitely the chief agent in the extension of vegetation on a virgin soil of the nature and under the conditions described as existing in this locality. The drupe-bearing *Pimelia prostrata* was found as high as about 850 metres, but I am of opinion that the seeds of even this plant may have here been dispersed by wind after their surrounding pulpy matter has been desiccated. The pulpy-fruited *Coriaria* and *Coprosmas* of the lower slopes are undoubtedly spread mainly by birds.

Twenty-five years after the eruption of Krakatau near Java, Ernst (4, 6) found that the three factors instrumental in the re-establishment of vegetation on the island were sea currents, wind, and birds. The determination of the agencies of distribution was in his case, however, by no means easy, but he gives sea currents as being probably responsible for 39 to 72%; wind, 16 to 30%; and birds 10 to 19% Krakatau is distant 11½ miles from the nearest land with vegetation.

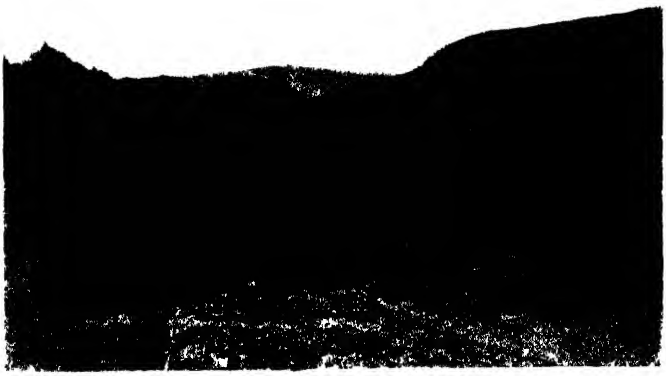
Though after the eruption of 1886 the western slopes of Tarawera Mountain were an isolated area, there were no sea currents to bring plants from other regions; but wind and birds exercised practically the same relative influence as they did in connection with the establishment of the new flora of Krakatau.

Willis (7) before referring to the classical case of Krakatau (Ernst 6) gives the case of Ritigala in Ceylon. It is an isolated mountain 765 metres high and separated from a wet zone area by a plain 40 miles wide with a dry climate. The summit of the mountain has a wet climate and is populated by 103 wet-zone plants. Of the 103 plants, 49 had light fruits or spores suited to carriage by wind, 24 were suited to carriage by birds, and 30 were doubtful.

That wind should be such a preponderant factor in the dispersal of plants which have seeds with a special mechanism (e.g., pappus hairs), or which are very light is not surprising when one remembers that loess soils have been formed by accumulations of dust which has

[By courtesy of Auckland Weekly News.

FIG. 1.—Rift-like crater at south end of Mt. Tarawera from southern extremity of Lake Tarawera, showing flanks of mountain covered with volcanic ejecta—a few months after the eruption of 1886.



[E. Phillips Turner, photo.

FIG. 2.—About 48 metres above Lake Tarawera, in large, flat-floored wash-out, looking west towards lake. On floor is *Coriaria*, on sides are *Coriaria*, *Aristotelia*, *Nothopanax arboreum*, *Fuchsia*, *Hebe salicifolia* var., and two *Leptospermums*. On high spur on right is a dense and vigorous growth of above, with *Metrosideros*, *Knightia*, *Melicytus*, *Beilschmiedia*, tree-ferns, &c. Lake Tarawera is 314.5 metres above sea-level.

[L. Phillips Turner photo

FIG. 3 From same spot as Fig. 1, but looking towards south end of Mt Tarawera. The tall conical tree is *Eucalyptus globulus*. The dark mass near summit of mountain is rocky cliff.

[L. Phillips Turner photo

FIG. 4.—From the same spot as Fig. 3, but looking north-west across Lake Tarawera. A clump of *Pittosporum tenuifolium* (about 7 metres high) and *Coriaria* (about 5 metres high). Under the shrubs is a carpet of *Danthonia*, *Hypochoeris*, *Acaena sanguisorbae*, &c. Frequent patches of *Raoulia*, shrubs becoming sparser.

[E. Phillips Turner photo

FIG. 5.—Near top of the big rift on southern end of Mt. Tarawera, looking easterly across crater-rift. On cliffs are odd shrubs of *Coriaria*, and *Gaultheria oppositifolia*, the latter occasionally on the scoria slopes. Altitude roughly 853 metres.

[Miss Rosa Hume, photo.

Fig. 6—Showing the rift-like crater extending down the south-western flank. Taken in February, 1927, from about one mile from the easternmost end of Lake Rotomahana. Vegetation mainly *Coriaria arborea* and *Pteridium esculentum*.

[Miss Rosa Hume, photo.

Fig. 7—Tarawera mountain as in February, 1927. New vegetation at Wairoa Village at the western end of Lake Tarawera. On the left are chiefly *Aristotelia*, *Weinmannia racemosa*, *Coriaria arborea*, *Coprosma robusta*, *Pteridium*, &c. On the right the tree is an exotic, its species not noted at the time.

been transported by wind from mountains distant sometimes several hundreds of miles. Dust discharged at the eruption of Tarawera Mountain in 1886 was carried by wind and deposited as far as sixty miles from the mountain. On one occasion when on a steamer travelling to Sydney and about 500 miles from land, I saw thistle pappus floating in the air, though the pappus was not close enough for me to make sure that a seed was attached to it. Even such heavy matter as sand on a desert surface is transported hundreds of miles.

The establishment of the vegetation on this mountain during the forty years which have expired since the eruption in 1886 has probably *on the whole* been somewhat retarded by wild pigs, horses, and rabbits, as these animals will, when food is scarce, nibble off most unpalatable plants which, even if not destroyed, may be prevented from bearing fruit: moreover, the coarse sandy nature of the soil on the slopes of the mountain is such that it is much disturbed when walked over by animals, and consequently the establishment of plants on it is, in this way, further slightly retarded. In other localities I have observed that wild pigs and horses spread brier (both animals will eat the berries), but in the particular locality herein dealt with I saw no brier to be spread. Other animals and man have had no detectable effect on the re-establishment of the vegetation on the locality now dealt with. Though wind has undoubtedly been the chief factor in the repopulation with plants of the virgin area of Tarawera Mountain, this repopulation has taken place from localities close to the virgin area, as has been shown by Cockayne (5) in his third edition of *New Zealand Plants and Their Story.*

Owing to shortness of time I could not explore the country laterally from the route by which I ascended the mountain; but there is no doubt that the re-establishment of plants on the south-western slopes of the mountain is taking place far less quickly than it is on the north-western slopes, and also, along the route taken by me, there are far fewer genera and species than those noted by Aston on the north-west.

North of the point where I landed, along the lake, and sometimes extending to about 200 metres in altitude up the mountain, a young forest is forming. The components of this forest have been fully given in Aston's paper, but I may add that at present it is just emerging from a condition of even growth, and the tall-growing trees *Metrosdieros tomentosa*, *Beilschmiedia tawa*, *Knightia excelsa*, and *Weinmannia racemosa* are now shooting above the smaller trees *Aristotelia serrata*, *Pittosporum tenuifolium*, *Nothopanax arboreum*, *Fuchsia excorticata*, *Geniostoma ligustrifolium*, *Dodonea viscosa*, tree ferns, and shrubs, and will form the top story of an ultimate high forest. Of the leading trees the *Knightia* is prominent by reason of its evenly conical growth-form. Of the plants noted there were nine exotic species, and of these three had become established through the agency of wind, three through the agency of animals, and three were of doubtful origin.

It is interesting to state that in the shrubby growth shown in Fig. 3, I found a solitary blue-gum (*Eucalyptus globulus*) which is an

exotic. This tree was about 12.2 metres high, and as there is no blue-gum growing at a closer point than Wairoa, about five and a-half miles away and across the lake, it seems reasonable to conclude that the seed must have been carried by wind to the spot where the young tree is now growing. The age of this tree would probably not exceed about 13 years, as the blue-gum is of exceptionally quick growth.

Shortness of time prevented my making a more comprehensive examination of the new surface of Tarawera, but the foregoing observations are probably worth recording for use by future students of what is going on in that region.

LITERATURE REFERRED TO.

1. ASTON, B. C., 1916. "The Vegetation of the Tarawera Mountains, New Zealand." *Trans. N.Z. Inst.*, vol. 48, 1915.

1a. ASTON, B. C., 1916. "The Vegetation of the Tarawera Mountain, New Zealand: Part 1, the North West Face." *Journ. of Ecology*, vol. 4. No. 1.

2. COCKAYNE, L., 1908. "Report on Botanical Survey of Tongariro National Park, *Lands Department Report*, Wellington.

3. COCKAYNE, L., 1910. *New Zealand Plants and Their Story*, p. 54, Wellington.

4. COCKAYNE, L., 1919. *New Zealand Plants and Their Story*, 2nd Ed.; pp. 194-198.

5. COCKAYNE, L., 1927. *New Zealand Plants and Their Story*, 3rd Ed: p. 104.

6. ERNST, A., 1908. *The New Flora of the Volcanic Island of Krakatau* (trans. by A. C. Seward), Cambridge.

7. WILLIS, J. C., 1922. *Age and Area*, Cambridge.

On Some Alcyonarians from New Zealand Waters.

By W. B. BENHAM, D.Sc., M.A., F.R.S., F.N.Z. Inst., Hutton medallist.

[*Read before the Otago Institute, 6th December, 1927; received by Editor, 20th December, 1927; issued separately, May 12th, 1928.*]

THE only members of the Order Alcyonacea enumerated in Hutton's *Index Faunae Novae Zelandiae* are the two species — ***Anthopodium australe*** Verrill, and ***Lobularia* (*Alcyonium*) *aurantiaca*** Quoy and Gaimard; of the Order Pennatulacea, *Virgularia gracillima* Kolliker; and of the Order Axifera, the species ***Primnoella australasiae*** Gray; all of which have been obtained in the waters immediately around the Dominion; the other Alcyonarians there listed are from the neighbourhood of the Kermadecs.

Since the date of publication of the *Index* another pennatulid has been described by myself from Doubtful Sound on the west coast of the South Island, *Sarcophyllum bollonsi* (Benham, 1906).

In the present paper I give an account of five species, of which four are new; these five fall into four families and belong to three of the Orders of Alcyonarians, as will be seen in the systematic summary below in which all the known representatives of the Sub-class Alcyonaria from our neighbourhood are shown.

It is only very rarely that naturalists in New Zealand have the opportunity of collecting in deep waters off our coast, and very little systematic collecting has been done even in the littoral zone, so that there are no doubt other members of the group still waiting discovery.

As will be seen from the following accounts of new species, we owe some of them to the fact that the Government have from time to time sent out ships in connection with the examination and extension of the fisheries; on some of these occasions the Hon. Geo. M. Thomson was fortunately on board, and it is due to his enthusiasm for zoology that some of the new species were obtained; and quite recently I have received marine specimens of various kinds from Lieut. T. A. Vickers, R.N.R., of H.M. Cable-ship "Iris," who has during the last year or two been good enough to send me material collected from considerable depths. I wish here to acknowledge with gratitude the generous help I have received from Commander Hughes in allowing his officers to collect for me.

The "Challenger" gathered only two Alcyonarians from these seas, namely the pennatulid *Virgularia gracillima*, which was later found by the late Dr. Dendy (1896) in Lyttelton Harbour; and the gorgonid ***Primnoella australasiae***, which had previously been recorded from Bluff Harbour by Verrill (1876). The genus is defined and figured in the "Challenger" Report (1889, p. xlix) and the species fully described by Verrill (loc. cit. p. 88).

Class ANTHOZOA.
Sub-class ALCYONARIA.
Order 1. STOLONIFERA.
Family CORNULARIIDAE.
Clavularia thomsoni n. sp.
Anthopodium australe Verrill.
Order 2. ALCYONACEA.
Family ALCYONIDEA.*
Alcyonium aurantiacum Quoy and Gaimard.
Anthomastus zealandicus n. sp.
Anthomastus phalloides n. sp.
Order 3. PSEUDAXONIA.
Family BRIAREIDAE.
Sub-family SPONGIODERMINAE.
Spongioderma (?) *vickersi* sp. n.
Order 4. AXIFERA.
Family PRIMNOIDAE.
Primnoella australasiae Gray.
Order PENNATULACEA.
Family VIRGULARIDAE.
Virgularia gracillima Kolliker.
Family PENNATULIDAE.
Sarcophyllum bollonsi Benham.

CLAVULARIA Quoy and Gaimard.

Clavularia thomsoni sp. n. (Figs. 1-5.)

Collected by the Hon. G M. Thomson, while on board the G.S.Y. "Hinemoa" in 1915, in Foveaux Strait.

The colony, white in colour, is growing on the costate surface of a simple coral, presumably a species of *Caryophyllia* as the calyx is circular in section; the coral was covered with an encrusting sponge containing needle-like spicules; issuing through this coating of sponge near the lip of the calyx are five polyps, attaining a height of 5 mm., which are so densely and completely covered with calcareous spicules as to give the impression that they are madreporarian corals, independent of one another. It was only on removing the sponge that it was seen that these polyps are in reality connected with each other by a stolon creeping over the surface of the *Caryophyllia*.

The stolon is a narrow, flattened band densely coated with calcareous spicules; it is not much wider than the polyps it bears. It commences on the outer surface of the calyx near its upper end, ascends obliquely to the lip, passes along this for a short distance and then descends into the cup: so that one polyp arises from deep within the cup; this is probably the oldest; two more are just within the lip; two on the outer surface; and in addition there are indications of

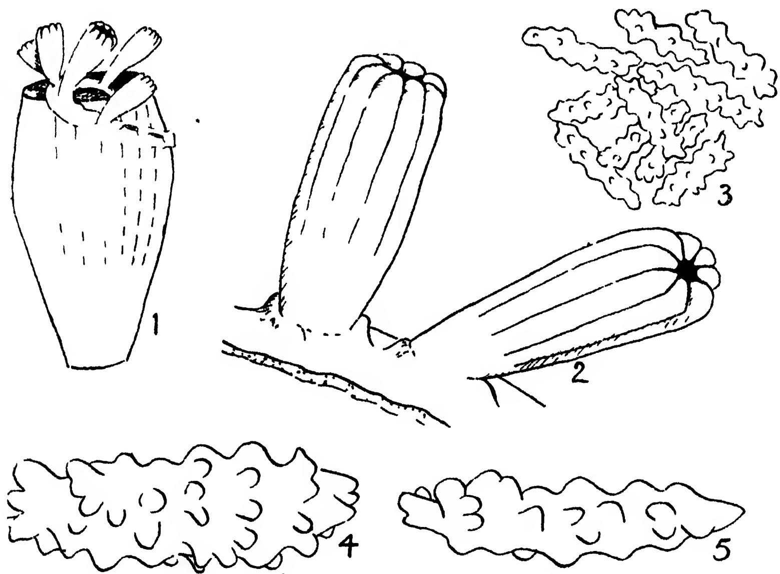
*Wright and Studer in the Section on Geographical Distribution (p. 295) includes "New Zealand" amongst the habitats of the genus *Sarcophytum*; but I have failed to find the reference to any species that has been recorded from here.

two others which appear to be mere buds, scarcely rising above the stolon.

The polyp or "anthocodia," is nearly cylindrical; its length of 5 mm. being rather greater than twice the diameter; the base is slightly narrower than the distal extremity; the tentacles are in each polyp withdrawn into the column. The surface of the polyp is marked by eight shallow and narrow furrows, separating as many ridges which are distally continuous with the bases of the retracted tentacles, so that the free end presents the appearance of an eight-rayed star or rosette.

The base of the polyp is surrounded by a very slightly raised cushion where it springs from the stolon.

The whole surface of the polyp is densely encrusted with spicules, so as to appear almost solid. The spicules are comparatively long, but stout rods, disposed lengthwise along the column, touching, even over-



FIGS. 1—5 *Clavularia thomsoni.*

1 A simple Coral, after the removal of the encrusting Sponge, with the colony of *Clavularia* creeping over the surface of the calyx (nat. size).

2. Two polyps springing from the flat ribbon-like stolon (x 8).

3 A portion of the stolon (x 40) showing the densely massed spicules.

4 A spicule from the body wall of the polyp (x 260).

5. A spicule from the stolon (x 260).

lapping, so that their outlines are individually difficult to trace; they look almost like scales; they do not project from the surface but are entirely embedded in the mesogloea.

After treatment with potash (boiled on the slide) they do not separate at all readily, being evidently bound together by the organic matter, but when sufficiently isolated they are found to have the form of short, broad rods, very rugose with numerous short rounded knobby

processes, closely set and apparently in whorls. A few slender spindles also occur throughout the skeleton, but become recognisable only after treatment with potash. The tentacles are provided with similar spicules and so is the stolon.

These spicules measure from 0.12 mm. to 0.27 mm.; the shorter ones being in the upper part of the column, the longer in the lower part. Measurements are: Length 0.12 with diameter 0.36 mm.; another gives, 0.18 by 0.054 mm.

I have been unable to study the structure of the delicate stolon.

Remarks: So far as I have been able to ascertain, this form belongs to the genus *Clavularia*; though the suspicion has crossed my mind that it may be Verrill's *Anthopodium australe,* of which unfortunately no figure is given by the author. On the other hand Hickson (1895) expresses the opinion that this genus is closely related to *Callipodium* on the one side and to *Telesto* on the other, and so should be placed in the group Stolonifera. But the colony under discussion resembles in various ways *Clavularia ramosa* Hickson, from Australia in its general appearance; the polyps recall those of *C. cylindrica* Wright and Studer, which was found at Tristan d'Acunha; while in other respects it seems to be allied to *C. flava* Hickson. In all these species the spicules are referred to as " forming a dense armour" or as being " locked together to form a compact skeleton," as in the present form.

It may be convenient to zoologists in New Zealand to include here the account given by Verrill of *Anthopodium australe*, so that any who may have the opportunity of collecting in Bluff Harbour may be able to recognise the species; and the account in the Bulletin U.S. Museum is not easy of access.

Generic characters copied from the " Challenger" vol. 31, p. 15.

> " The colony is incrusting, firm. The polyps are large, prominent, retractile within tubular verrucae. The surface of the coenenchyma and verrucae is minutely granular with dentations of the spicules projecting. These spicules are irregular in outline and closely united together. The spicules, in addition to those mentioned, are spinose spindles and clubs."

On p. 298 it is stated that. " The only species is recorded from Fort Macon, north coast, North Carolina." Either the authors overlooked the record from New Zealand, or the species had been removed to some other genus; I have been unable to trace it.

From Verrill (1876, p. 76) *Anthopodium australe*:--

> " Polyp cells cyclindrical or somewhat clavate with distinct sulcations at summit, in contraction; the surface covered with small rough spicules: the height variable up to a quarter of an inch or more. They arise from a thin encrusting or stolon-like coenenchyma, which is coriaceous and roughened with spicules, like the polyp cells. The polyps are irregularly scattered along the coenenchyma, which creeps over the upright axis of *Primmoella*. Colour, light orange-red. Height of polyp-cells, mostly 2 mm.—6 mm.; diameter, about 1.5 mm."

Then follows a detailed account of the different kinds of spicules. " Bluff Harbour, New Zealand on *Primnoella australasiae*."

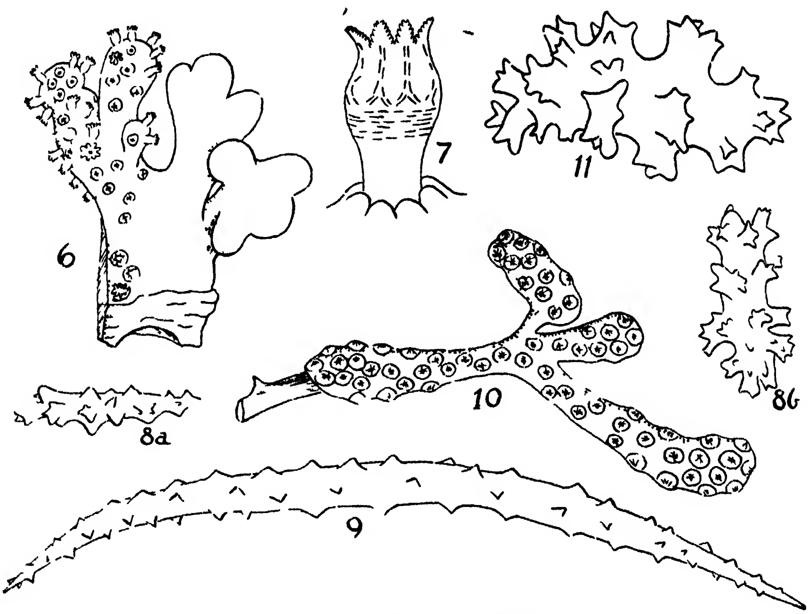
ALCYONIUM Linnaeus.

Alcyonium aurantiacum Quoy and Gaimard. (Figs 6-11.)

Hutton, in his *Index* attributes this species to the genus "Lobularia," which is now abandoned. He makes a slip in using the name of Lamarck for the species. It may be mentioned, too, that Quoy and Gaimard omit the "i" in *Alcyonium*. The following is the diagnosis given by them—to their species—

"Alcyonum, parvum, molle, ramosum, ramis obtusis; polypis elongatis, clavatis, albis; tentaculis brevissimis rotundatis."

With respect to the last statement, their figure (pl. 22, figs. 16-18) shows the tentacles quite evidently retracted; they did not see them



FIGS. 6—11 *Alcyonium aurantiacum*

6 The specimen A from Mahia Peninsula region, the erect form of the species (nat. size). A branch and part of the stalk had been cut from the left side, the polyps are omitted from the right side of the sketch.

7 An anthocodia or polyp (× 10).

8 Spicules from the coenenchyme (× 40)

9 Spicule from the wall of the anthocodia (× 260).

10. The creeping form from Dusky Sound (nat size).

11. Spicules from the coenenchyme of this form (× 260).

entirely expanded, so that they are in error in saying that they are round.

In the text they state further that the colony measures two to three inches; it is orange on colour, with white tentacles and the polyps are transparent.

The specimen was obtained in the estuary of the River Thames, (in the North Island) in water of 8 to 10 fathoms.

The figure represents a colony with a long wide sterile stalk supporting half-a-dozen finger-shaped branches, some of them lobed. Figures of the spicules are given.

That is all we know of the species up to the present time, for it has not been met with, or referred to, by any naturalist since 1834.

Of this species I have three specimens, colonies of very different form and colour, but as all three present the same general arrangement of the polyps and the same type of spiculation, I refer them to the same species, for it is acknowledged by those who have made a study of this genus that external features are highly variable within the same species.

It will be convenient, however, to deal with each of the specimens separately.

Some years ago I sent a portion of two of these colonies to Professor Hickson, of the Manchester University, to ask his opinion as to their specific nature, for he has made an extensive study of the group Alcyonaria and especially of the genus *Alcyonium*. He replied that he believed each of them, as well as a young colony that I had collected in 1909 at Carnley Harbour in the Auckland Island, which I sent to him at a later date, belonged to this species.

Specimen A was collected by the late Mr. L. F. Ayson, during the cruise of s.s. "Doto," in 1901, at a station near the Mahia Peninsula, on the east coast of the North Island.

The colony,* which is of a pale brown colour, consists at present of a short stalk or sterile region, some 5-7 mm. in length, and a lobed polypiferous region. The stalk has a smooth surface, but is somewhat wrinkled; the proximal extremity of which is hollowed out as if to form the attachment to a shell or stone. The polypiferous region presents a short basal portion which soon divides into three rather flattened lobate branches, lying in one plane; each branch gives origin to a few short, broad, rounded lobes. The entire surface of this polyiferous region is covered with "anthocodia" (Hickson) or polyps in the systematic sense.

The greatest length of the colony is 37 mm., of which the basal portion accounts for 12 mm. on one side; but it is much less on the other side where the first branch springs; it has a diameter of 20 mm., and is nearly cylindrical; but as a piece has been cut off from one side for the purpose of transmitting to Dr. Hickson, probably this side was not so long as 12 mm., and presented a branch corresponding to the one on the other side.

The breadth of the polypiferous region is 40 mm. across the branches.

The coenenchyme is paler in tint than the anthocodiae; it is white and translucent; the anthocodiae are very pale brown (possibly yellow in life), and when fully extended measure 2 mm.; most are completely retracted; others more or less incompletely. They are rather widely spaced, though towards the ends of the branches or

* I cut off a part of the stalk and a branch from the left side to send to Dr. Hickson.

lobes they are much closer together, so that they nearly touch one another around the extremities of the lobes.

The fully extended anthocodia is somewhat tub-shaped, being narrower where it springs from the coenenchyme, then swelling out in the middle and is again constricted just below the tentacles. The base is surrounded by rounded lobules, which project slightly from the ceonenchyme, like a small "calyx"; and on contraction these lobules close over the anthocodia. The tentacles have on each side a row of short, rounded, closely set pinnules.

The column of the anthocodia is supported by spicules, which near the base have the form of long spindles disposed horizontally in about six tiers; above this the spicules are arranged in converging groups, as usual directed towards the tentacles, where they assume a longitudinal arrangement, passing up the back of the tentacle in bundles.

The spindle-shaped spicule is a long curved rod, pointed at each end, with laterally placed "thorns" or sharp points along its length. These spindles measure from 0.16 to 0.27 mm. in length, with a diameter of about 0.036 mm.

In the coenenchyme the commoner form of spicule is a shorter or longer rod, with rounded ends and covered with rounded "knobs"; these vary from 0.12 mm. to 0.054.; and even 0 01 mm.: the most numerous are the medium sized.

Specimen B.—This colony was collected by Hon. G. M. Thomson, in Tasman Bay, in the north of the South Island, during a cruise on the "Doto," in 1900, in connection with the Fisheries Department. I referred to it in a brief summary of the results, printed in the Report by the Minister of Marine; and I described it in the following terms:—

"A handsome, Indian-red species of Alcyonium was obtained in Tasman Bay. It is attached to shells by a short, broad stalk, which bears a number of short rounded lobes or branches covered with polyps, which are white, with an orange band just below the white tentacles."

Its colour is still, after being 27 years in alcohol, of that "Indian-red" colour that it had when it reached me in 1900. But the polyps are now yellow, due perhaps to the fact that the orange pigment below the tentacles has diffused during these years.

It was of this colony that I sent a portion to Hickson and what remains here is too small for me to determine its shape; it is a mere rounded irregular mass, for no doubt I sent the greater part to Manchester. This fragment is now more contracted than is Specimen A, so that the anthocodiae are pressed tightly together, touching one another so that no coenenchyme is visible between them. The fragment seems therefore to be the end of a branch. Each of the anthocodiae is surrounded by a short calyx-like cushion at its base, which is evidently the same as the lobes referred to above, but exaggerated by the great contraction of the whole colony.

The anthocodiae are yellow, with white tentacles; when fully retracted each anthocodia is covered over by these eight lobes of red coenenchyme; but when only partially retracted, that is with the

tentacles partially withdrawn, these appear as eight white knobs within the red lobes.

It was no doubt to these retracted polyps that Quoy and Gaimard refer in their account of the species; they did not see the fully expanded tentacles.

The colony is male; the white "spermagems" being visible in some of the polyps, forced upwards no doubt by the strong contraction, when the colony was immersed in the preservative.

The spicules, which have a deep yellow tint, are of the usual two forms—

(*a*) Short, broad rods with very numerous stout, knobby processes, arranged apparently in whorls; they average about 0.09 mm. in length;

(*b*) Longer spindles with thorns, the length being from 0.12 to 0.18 mm.

On the wall of the anthocodia these spindles are longer and stouter and are also curved, and attain a length of 0.5 mm.

Specimen C.—Was collected more than thirty years ago in Dusky Sound, in the S.W. of the South Island, by W. Docherty.

It is a creeping colony, growing round the stem of what appears to be an Antipatharian; its colour is a yellowish-brown, a good deal darker than Specimen A.

It consists of a central portion, along the axis of the support, and two unequal branches springing from the two sides at approximately one-third of the distance from one end of the central region; these branches are swollen distally.

The main axis measures 50 mm. with a diameter of 6 mm. near each extremity, but half this width in the middle and at the point of origin of the lateral branches. One branch forms an angle of about 30° with the axis, and is 30 mm. in length, with a diameter of 8 mm. near its rounded end. The other branch also arises at a similar angle: it is at first very narrow, but soon enlarges and swells out into a cylindrical mass of about 15 mm. long and 7 mm. wide, which is at right angles to its narrow basal region.

The anthocodiae are distributed all over the surface as in the other specimens, and are much more closely arranged near the extremities, while in the middle area they are more distant.

The spicules are of deep yellow colour and have the same form as in the other two specimens.

Remarks.—Although it is impossible to be sure of the identification of these specimens with Quoy and Gaimard's species, since they, like other naturalists of the period, contented themselves with external features only (which we now know are of little value); yet since the only species hitherto recorded from the waters of New Zealand is this one, which was obtained from the estuary of the Thames (North Island), the probability is great that we are dealing with the same species.

A. aurantiacum, as now described, differs from the Australian *A. etheridgei* (Thomson and Mackinnon) as well in its colouration as in its spiculation; for I find no " club-shaped" spicules with one end

much wider than the other, such as these authors' figure on Pl. 67, fig. 4.

The creeping colony from Dusky Sound differs also from *A. reptans,* as figured by the same authors, in that the anthocodiae are much more closely arranged in the New Zealand form, as well as in other details. It differs from any of the species described from S. Africa and from those described on the "Challenger" Report; but I have to confess that my library, and those to which I have access, do not permit me to make a complete comparison with other species of the genus.

ANTHOMASTUS Verrill.

Anthomastus zealandicus sp. n. (Figs. 12-19.)

This handsome Alcyonarian was collected by Lieut. Vickers in 517 fathoms at a spot 21 miles north of Doubtless Bay near the extreme north of the North Island.

It is a deep carmine-coloured, mushroom-shaped colony with very large polyps, of the same colour as the coenenchyme.

The height of the colony is 30 mm., of which the cylindrical stalk or sterile region occupies 15 mm. with a diameter of 12 mm. The "capitulum" is circular in outline and very convex; its margin is somewhat undulating owing to the presence of polyps near the edge; its diameter is 25 mm. and it overhangs the stalk by 4 mm.

The capitulum carries only about two dozen large "autozooids," a few of which are fully expanded, though they have been compressed by the walls of the phial into which the colony was placed. Others are more or less retracted, and some fully so. When the tentacles are retracted they are incurved as in *Alcyonium.*

The height of the extended anthocodiae or polyps is 8-10 mm., and the diameter at their base 5 mm. Over the upper part of the capitulum they are more widely spaced, being about 4 mm. apart, while near the margin, which is apparently younger, they are nearer together, so as almost to touch.

The surface between these autozooids is entirely covered with the "siphonozooids," which appear as small round pustules, each with a minute apical pore, the mouth of the zooid.

The tentacles have one row of long narrow pinnules along each of the sides, which are as long as, or even longer than, the width of the tentacle.

The base of the autozooid is surrounded by a circular cushion, standing up slightly from the coenenchyme.

A portion of the surface of the capitulum was cut tangentially and the whole "skin" is seen to be supported by long spindle-shaped spicules lying in all directions, with a dense superficial layer of short, broad "knobby" rods.

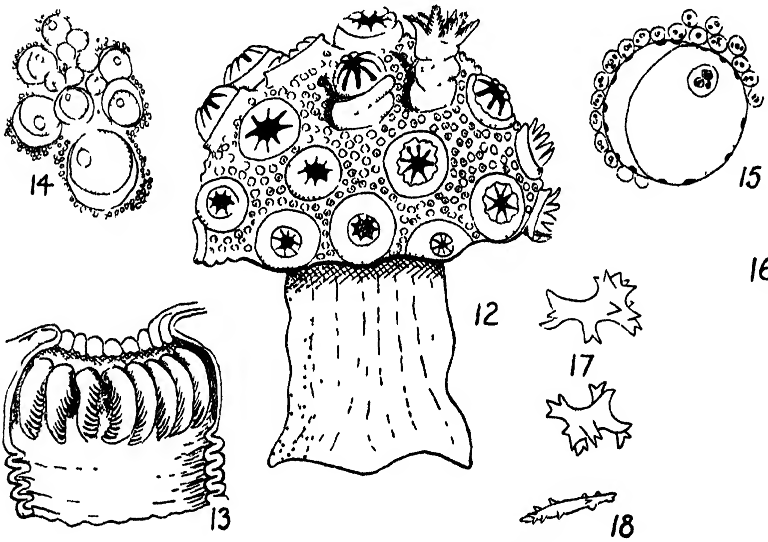
The spicules are red, and the colour is not affected by boiling in caustic potash; it is this colour which gives the colour to the colony. The short superficial spicules of the coenenchyme measure from 0.054 to 0.07 mm.

The spindles of the deeper layer measure from 0.36 to 0.6 mm. the majority are 0.5 mm.

In the anthocodia the same two kinds of spicules are present, but those of the tentacles are rather shorter spindles, from 0.27 to 0.45 mm. in length.

In the wall of the stomodaeum the spindles are very much shorter, and are arranged in circles or transverse tiers, allowing the folding of the wall on contraction.

On the stalk the spindles are disposed lengthwise and the short knobby rods are very densely arranged; here the spindles have a



FIGS 12—19, *Anthomastus zealandicus*.

12.—The entire colony (× 2) The small circles between the large polyps are the siphonozooids.

13.—The upper portion of an autozooid opened to show the manner of retraction of the tentacles (x 4).

14.—An ovary (× 260).

15.—An ovum much enlarged.

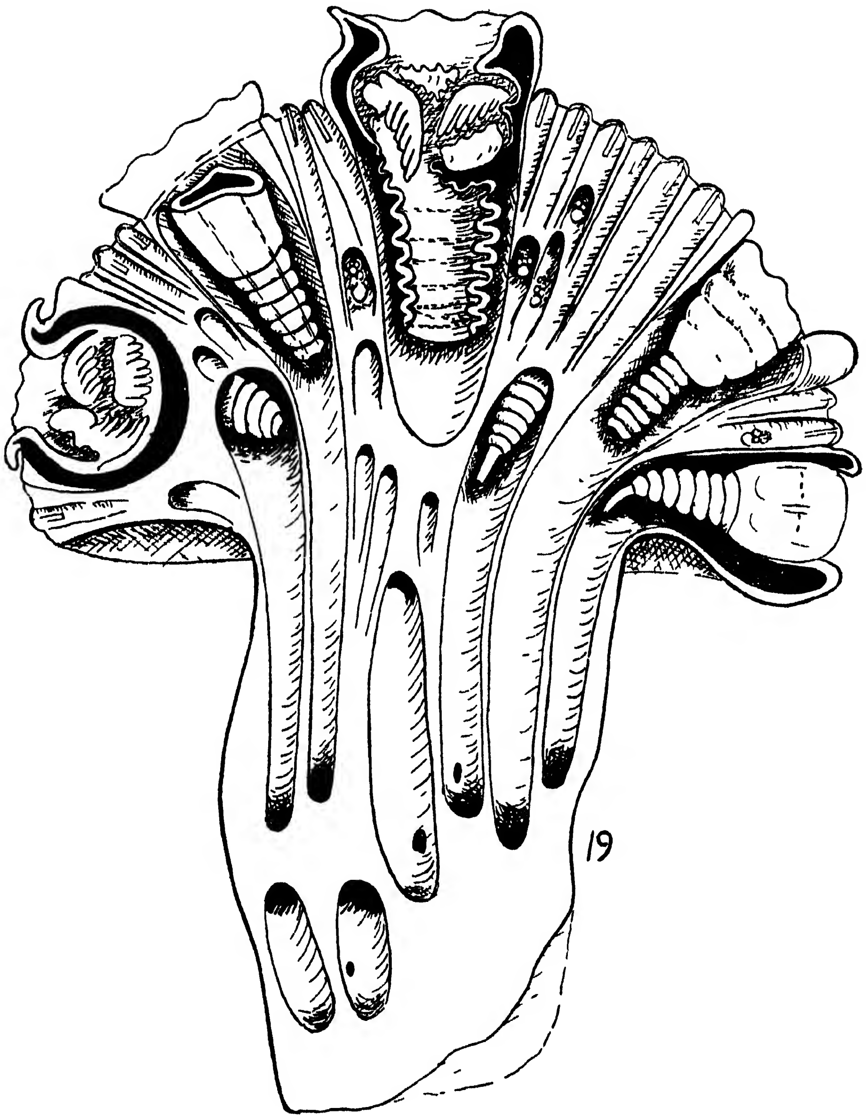
16.—One of the throny spindles (× 260).

17.—A knobby rod from the superficial layer of the coenenchyme (× 260).

18.—One of the short spindles from the stomodaeal wall (x 260).

length of 0.36 to 0.45 mm., and the knobby rods from 0.054 to 0.07 mm.

In a longitudinal section of the colony each autozooid is found to be continued down the stalk to the base, as is usual in the family; it appears to be independent of other cavities except that near the lower end there are wide transverse canals putting the autozooids into communication. The cavities of the siphonozooids are also continued downwards for a long way, but I am unable to say how they terminate. There are no longitudinal canals such as are described by Moseley for



19.—A longitudinal section of the colony (x 4). The plane of the section passes through autozooids at different levels; in the centre it almost bisects one, and the tentacles are seen inflexed, the lower end of the stomodaeum has escaped from the section; right and left are autozooids in which the tentacles are not involved, but the stomodaeum is present; some others partly appearing in the section show the termination of the stomodaeum. Some of the siphonozooids contain ovaries.

Sarcophytum, but the entrances of transverse canals can be seen in the walls of the siphonozooids.

The stomodaeum of the autozooid is very long and tapered; it consists of two regions,— (*a*) the much longer upper region which is highly muscular and on contraction is thrown on to a series of close folds or pleats; and (*b*) a short non-muscular narrow tubular region at the lower end.

On the contraction the tentacles are not merely withdrawn into the body but are inflexed with their apices directed downwards towards the stomodaeum.

The siphonozooid has a short simple tubular stomodaeum, suspended by eight mesenteries, of which however only four reach to its lower end, and only two are continued down the whole length of the zooid.

In several of these siphonozooids there are ovaries, which are absent in the autozooids, and in this feature the colony differs from *Sarcophytum*. Each ovary has the form familiar in *Alcyonium* — a bunch of eggs of increasing sizes. Each egg is enveloped by a distinct unilaminar investment or follicle of flat cells, outside which are rounded cells of larger size which seem to be merely adherent and do not form a definite layer. These cells are granular and colourless, but contain one, two or sometimes three shining red granules; similar cells block the mouths of the siphonozooids, and I take them to be Zoochlorellae.

Remarks: In the fine account of the structure of *Sarcophytum* by Moseley (1881, p. 117, Pls. 1, 2) the autozooids are referred to as the "sexual zooids" and the siphonozooids are contrasted therewith as non-sexual; Wright and Studer in their "Report on the Alcyonaria" (1889) state that *Sarcophytum* purpureum Dan. and Kor. has siphonozooids which bear the sex-organs, and they therefore place this species in the genus *Anthomastus* Verrill. The red spicules, the shape of the spicules as well as the sexuality of the siphonozooids which I describe for the present species, agree with their account of the two species of Anthomastus described in that Report.

Hickson (1900, p. 74) stated that he considered the facts insufficient to separate the genus from *Sarcophytum*, but in 1904 (p. 217) accepts Verrill's genus and redescribes *A. grandiflorus*.

Another feature in which the present species differs from *Sarcophytum* is in the absence of longitudinal canals which serve to connect the various zooids. Further, Moseley states that the tentacles are pulled downwards when the autozooid is contracted and so figures them, as does Pratt (1903) for *Sclerophytum* (pl. 30, fig. 22), whereas in the New Zealand species they are inflexed, and the apices are directed downwards.

It may be mentioned that in *A. canariensis* and in *A. steenstrupi* the autozooids are, as in the present species, few and large (see Challenger Report, 1889).

The figures given of the spicules in the species of *Sarcophytum* in that Report, as well as in other accounts, show that the "spindles" are not much longer than the "knobby rods," whereas in *Anthomastus* they are a good deal longer; though in none do they reach the great size shown by Hickson (1900) for *S. trochiforme* from South Africa. This species I should have referred to the genus *Anthomastus*,

but he prefers to regard it as "intermediate" between the two genera, though he gives no details of anatomy which will enable us to decide the matter.

As to the shape of the colony, although the mushroom shape was formerly regarded as almost diagnostic of the genus *Sarcophytum*, yet as Pratt has shown, this shape may occur in the young forms of *Lobophytum* and of *Sclerophytum*. *Anthomastus* has usually the form of a rounded polypiferous region, and I am not aware that hitherto any species has been described with the very definite mushroom form of the present species. All of which indicates how difficult, if not impossible, it is to allocate the species of these animals to their real genera from external form alone, and illustrates the necessity of examining the finer anatomy.

Anthomastus phalloides n. sp. (Figs. 20-24.)

A single colony was obtained by Hon. G. M. Thomson during the experimental fishery cruise in the G.S.Y. "Hinemoa," in 1915. Unfortunately neither the exact station at which it was dredged nor the depth was noted, but it seems probable that it was somewhere in Foveaux Strait.

The specimen had been forced into a phial too small for it, with the result that it is somewhat distorted; it is abruptly bent near its base, and at one point was ruptured, but by careful manipulation I was able to make the following measurements.

The colony is finger-shaped, pale yellowish in colour, and consists of a short sterile stalk and a long polypiferous region. The surface of the stalk is smooth, though somewhat wrinkled by contraction; it measures 12 mm. in length, and has a diameter of about 17 mm. But this is not its real length, for on cutting down the stalk I found that the cavities of the various polyps opened at the lower surface and that sand had entered for a distance of some 7 mm. in the cavities. Hence the present base of the stalk which is concave and appeared to represent the base of attachment is in reality a cut surface, which has contracted in the centre and produced this concavity.

The polypiferous region, which is very distinctly marked off from the stalk, is 35 mm. in length and 12 mm. in diameter at its base, tapering slightly to 8 mm. near the rounded apex. The texture is firm and hard, and the surface between the autozooids is much wrinkled with narrow deep furrows running round the circumference, undulating and irregular, marking out ridges which widen and shorten or even disappear, so that the whole surface appears corrugated; it is on the widened parts of these ridges that the mouths of the siphonozooids are situated.

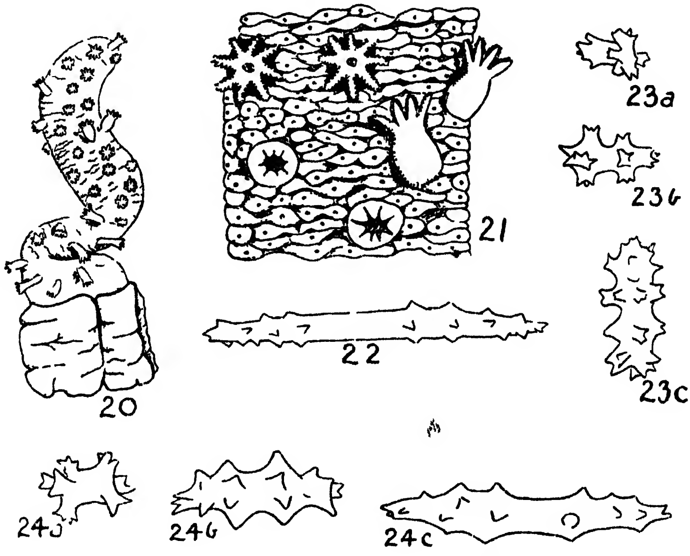
The autozooids are long, colourless and retractile, and widely spaced; they attain a length of 4 mm. from base to tips of the tentacles when extended. The column is transparent and has no spicules in its wall; some are fully extended, others in various degrees of retraction.

The spicules of the polypiferous region are of the two types—(*a*) short, knobby rods from 0.05 to 0.074 mm. in length; and (*b*) Thorny spindles of from 0.16 to 0.25 mm.

The knobby rods are so densely packed that it is difficult to detect the spindles through the screen formed by them.

In the stalk, at any rate in the outer layers, there are no spindles, but the knobby rods are here, too, very dense, and some of them are longer than in the upper region, attaining a length of 0.09 to 0.1 mm., but in the deeper parts of the colony as seen in a vertical section spindles are found, which are disposed parallel to the axis of the zooids, and are longer than those nearer the surface.

In the lower port of the polypiferous region the autozooids are about 5 mm. apart; in the upper part they become closer, till they are separated by only 2 mm.



FIGS. 20—24, *Anthomastus phalloides*

20—The colony, unnaturally bent (nat. size)
21—A portion of the surface of the coenenchyme (x 4). The small dots in the corrugated areas between the autozooids are the mouths of siphonozooids
22—A thorny spindle from the polypiferous region (x 260).
23—Knobby rods or "double crosses" from the superficial layer of the coenenchyme (x 260).
24—Spicules of various sizes from the stalk (x 260). (*a*) A double cross; (*b*) a knobby rod, (*c*) a thorny rod

There is no "cushion" at their base, the wall of the polyp passing directly into the coenenchyme.

Large spherical objects, which at first I supposed were ova, occur in several of the siphonozooids, but sections show them to be hollow spheres with a wall composed of several layers of minute cells; they are no doubt a stage in the development of spermatozoa to which name "spermagems" has been given. They have been forced upwards into this position by the strong contraction when placed in the preservative.

The colony bears considerable resemblance to *Acrophytum claviger* Hickson (1900, p. 74); this, however, possesses club-shaped spicules, much broader at one end than the other, which tapers to a

point, and spicules are stated to be rare in the deeper parts of the colony. Of *Alcyonium sarcophytoides* Burchardt, Stuart Thomson (1921, p. 157) gives a description of a colony which seems to have a similar form, but siphonozooids have not been definitely recognised therein.

SPONGIODERMA Kolliker.

Spongioderma (?) **vickersi** n. sp. (Figs. 25-31.)

A portion of an arborescent colony of a pale colour, consisting of a cylindrical stem, bearing short branches, with non-retractile polyps, the whole densely covered with spicules which project from the surface and render it rough.

It was collected by Lieut. Vickers, of H.M.C.S. "Iris," in 517 fathoms, at a station 21 miles north of Doubtless Bay, on the east coast of the North Island.

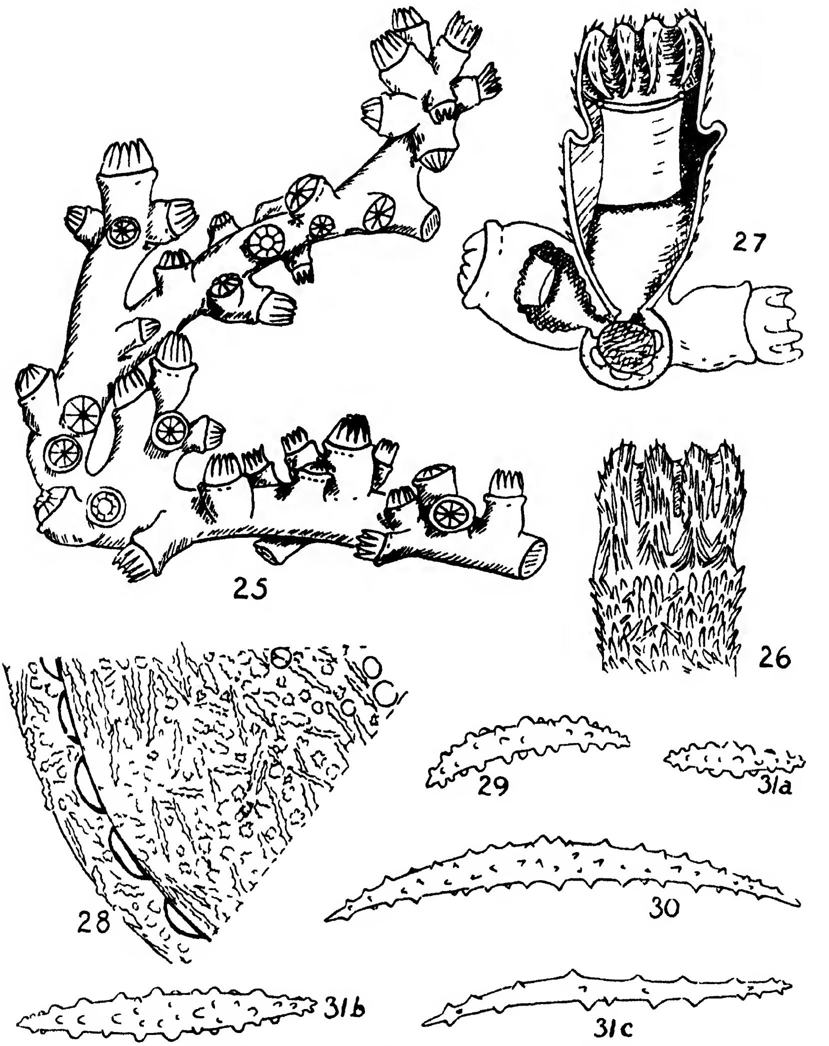
The cylindrical stem measures about 80 mm., but it had been put into a phial too narrow and too small for it, so that the stem is bent and some of the branchlets are broken off. This stem after bearing a short branch set on each side, each of about 12 mm. length, bifurcates into two similar branchlets at its termination. At the point of bifurcation the stem is broadened out and flattened, the diameter of the stem being 3.5 mm., and the broader portion 8 mm.

At the end of these branchlets the polyps are clustered together, but along the stem they are less crowded and irregularly spaced; they are of unequal sizes and the smaller are interspersed among the larger, though there is not much difference in the dimensions. The polyps are comparatively short and stout, measuring from 3 mm. to 4 mm. in either direction; each is slightly enlarged just below the tentacles, and the effect is enhanced by a constriction immediately below these, followed by a thickened rim at the upper end of the column. The tentacles are in every case more or less retracted, that is "inturned," but the bases are very prominent and separated from each other by deep furrows, so that at first one is led to suppose that the tentacles are in some instances fully extended.

A dissected polyp shows that it is only the tentacles that are retracted, this region being withdrawn for a very short distance into the upper part of the column, and so causing the circular rim above referred to. The stomodaeum is wide and extends about halfway down the polyp body; it has a thin wall, is without spicules and without muscles, except the strong circumoral sphincter; its wall is thus not pleated, but hangs straight down.

The inturned tentacles show 4-6 pairs of long and narrow pinnules.

The stem is composed of a superficial cortex or "sarcosome" investing very closely the central medulla or "axis." Between the sarcosome and the axis is a series of wide, shallow canals, running longitudinally; each is surrounded by mesogloea, but owing to the poor preservation I can detect no cellular lining. These canals are, however, continuous with the cavities of polyps, as is seen in a dissected specimen. The individual polyps are not directly connected



FIGS. 25—31, *Spongioderma* (?) *vickersi.*

25.—A portion of the colony (x 2). The apparent "tentacles" are in reality the bases of the inturned tentacles, with deep furrows between; in none of the polyps are they extended.

26.—The upper end of a polyp (x 6). The whole surface is roughened by projecting ends of spicules.

27.—A bisected polyp with two younger ones and a cross-section of the stem (x 6). Details are somewhat diagrammatic; the inflexed tentacles; the oral sphincter and the extent of the stomodaeum are seen; as well as the communication of the polyp cavities with the longitudinal subdermal canals of the stem.

28.—A portion of a transection of the stem (x 25), showing the "sarcosome" with its subdermal canals.

29.—A spicule from a tentacle (x 40).

30.—A spicule from the wall of a polyp near its base (x 40).

31.—*a*, *b*, *c*: Spicules from the stem (x 40); the main mass consists of types like that labelled *b*.

with one another, but each springs from one of the canals, which possibly branch as they run along the stem; but I did not follow them out.

The entire surface of the colony, the polyps and the tentacles, is roughened by the projecting points of spicules, which are very densely arranged and crowded together to form a sort of armour. Even the projecting points are covered with a thin stainable membrane, the mesogloea, but the ectoderm had disappeared.

The spiculation differs somewhat in different parts; the column is provided with short, stout, round-ended rods with many rounded knobs. These spicules, though arranged rather irregularly, in the upper part of the column, tend to take on a longitudinal position; some of these project from the surface. Besides these, there are some spindle-shaped, or even bow-shaped, spicules.

Above the subtentacular constriction the spicules become longer spindles, with thorny processes, and become disposed in converging groups directed towards the bases of the tentacles, the outer surface of which is supported by very long spindles, arranged, of course. lengthwise, the points projecting considerably beyond the bases of the inturned tentacles.

On the stem, the superficial "sarcosome" presents a coating of obliquely and irregularly-disposed, short, knobby spicules, very densely fitted together, and below them occur longitudinally-disposed, long, thorny spindles.

The medulla or central axis consists entirely of spicules densely aggregated and with very sparse mesogloea; it presents no canals, but a few small sub-circular spaces occur towards the centre, which I take to be due to spicules having dropped away.

The spicules are rather more loosely packed towards the centre than peripherally, they are disposed both longitudinally and concentrically; spindles and knobby rods are present.

When boiled in potash, these two sorts are found to be accompanied by spicules of intermediate character, but the most numerous are long spindles with thorny outgrowths, and the short knobby rods. Taking the spicules from all parts of the colony, they range from 0.25 to 0.72 mm. in length, with a diameter varying from 0.036 to 0.07 mm.

Remarks: It is evident that this species belongs to the sub-family Spongioderminae in which the axis is devoid of "solenia" or canals. In the text books and other literature available I can find only three genera allotted to this sub-family; and from the diagnosis of *Spongioderma,* as given by Wright and Studer, it agrees most closely with this. It is certainly neither *Titanideum* nor *Iciligorgia*. The only species of *Spongioderma* that is mentioned in the "Challenger" Report is *S. verrucosum* Mobius, from Algoa Bay; and in it the polyps are "retractile into the calices." It is therefore with much hesitation that I place the new species within the genus; for in it the polyps are certainly not retractile; only the tentacular crown is partially withdrawn into the column of the polyp. But without literature, and with but very little knowledge of the group, I leave it here for some authority on the matter to place it in its proper genus.

LITERATURE CITED.

BENHAM, W. B., 1906. On a New Species of Pennatulid (*Sarcophyllum bollonsi*), *Trans. N.Z. Inst.*, vol. 39, p. 193.

DENDY, A., 1896. On *Virgularia gracillima* in Lyttelton Harbour, *Trans. N.Z. Inst.*, vol. 29, p. 256.

HICKSON, S., 1895. A Revision of the genera of Alcyonaria Stolonifera, *Trans. Zool. Soc.*, vol. 12, p. 325.

HICKSON, S., 1900. The Alcyonaria and Hydrocorallinae, of the Cape of Good Hope, *Marine Investigations in South Africa.*

HICKSON, S., 1904. The Alcyonaria of the Cape of Good Hope, Part ii, *Marine Investigations in South Africa*, vol. 3.

HUTTON, F. W., 1904. *Index Faunae Novae Zelandiae*, p. 315.

KOLLIKER, A., 1880. Report on the Pennatulida, "*Challenger*" *Reports*, vol. 1.

MOSELEY, H. N., 1881. On the Helioporidae and their Allies, "*Challenger*" Reports, vol. 2.

QUOY AND GAIMARD, 1834. *Voyage de découvertes de* "*L'Astrolabe*," vol. 4. Zoophytes, p. 277.

PRATT, EDITH, 1903, *Alcyonaria of the Maldives*, part 2.

THOMSON, A., and MACKINNON, D., 1911. The Alcyonaria of the "Thetis" Expedition, *Mem. Austral Mus.*, vol. 4.

THOMSON, J. STUART, 1921. South African Alcyonacea, *Trans. R. Soc. S. Africa*, vol. 9.

VERRILL, A. E., 1876. *Bull. U.S. Mus.*, p. 76.

WRIGHT and STUDER, 1889. Report on the Alcyonaria, "*Challenger*" *Reports*, vol. 31.

Food Values of New Zealand Fish.

Part 9: Tinned Toheroa and Toheroa Soup.

By JOHN MALCOLM, M.D.

[*Read before the Otago Institute, 8th November, 1927; received by Editor, 2nd February, 1928; issued separately, May 12th, 1928.*]

THE toheroa (*Amphidesma ventricosum*, Gray) is a bivalved mollusc found in the tideway of certain long sandy beaches, especially in the northern part of the North Island (1).

Unlike the oyster its double shell does not retain sea-water long enough to allow of it being marketed at a distance, but in recent years the shell-fish has been successfully canned, and has become widely known as forming the basis of "toheroa soup."

COMPOSITION.

Since it was unlikely that the composition would prove to differ much from that of the paua, oyster, or other shellfish, no systematic analysis was made, but certain data had to be obtained for the vitamin experiments which form the main part of this paper, and these are mentioned here.

The tinned toheroa used ("Shell brand"—put up by Meredith Bros., Tikinui) was found to have 74% water, 2.57% ether extract, and 1.57% ash. The ether extract was of a rich green colour, and showed a marked spectrum of chlorophyll. The tinned soup (Tiki-Toheroa medicinal broth, Northern Canneries, Ltd., Auckland) had between 9 and 10% solids of a similar green appearance to the foregoing.

VITAMIN-A CONTENT.

Methods: The contents of the tin were minced, and a weighed quantity, mixed with starch to form a leaven, was dried for some hours in a moderately warm oven. The weight was then made up with starch and extracted casein to that of the quantity of toheroa taken, or to some round figure. The whole was then ground to a fine meal and given as a supplementary ration to rats suffering from lack of vitamin-A. The basal diet on which these rats were otherwise fed consisted of extracted casein, rice-starch, hardened vegetable oil, "marmite" (vitamin B), salts (McCollum's mixture), and oxidized cod-liver oil (vitamin D) (2).

This method of feeding the material as a fine meal was adopted to secure uniform mixing, for the visceral part of the shell-fish is probably much richer in vitamins than the mass of the adductor muscle. The method is open to objections in that destruction of the vitamin is likely to take place during the drying in air, and, secondly, in that, when several rats occupy one cage, uneven distribution of the

combined daily ration may occur. In spite of these sources of loss or of irregularity, the results were positive and uniform as shown by the curves of growth.

In order to provide a basis for assessment of the amount of vitamin-A present in the different quantities of toheroa, the rations were given daily for a period of ten days (except in one case) and the observations on weight, eye, and other symptoms were continued till death occurred. In this way one obtains some idea of the amount of vitamin available for storage during the feeding period as well as for growth. In order to allow the rats to make the most of the material, the cages were not cleaned for some time after the dieting was begun, so that, if they chose to do so, they could eke out their stored vitamin by consuming some of their faeces. As the cages contained sawdust and fine shavings as bedding, no disagreeable odour was detectable. They were probably under more natural and more comfortable conditions than when kept in daily scrubbed metal cages without bedding and under what we would consider more hygienic conditions. It should also be mentioned that the stock rats from which the litters used were bred are kept on a diet of wheat and receive kitchen scraps twice weekly. Basal diet is begun before the young are weaned, usually about the 20th day.

Results: *Litter Al*, six rats, were given basal diet on the 24th day and were weaned at 28 days. They were separated into three groups, I, II, and III. Only the growth curve of Al, II, is shown (Chart 1). This group consisted of two does. By the 96th day of age their eyes were noted as beginning to be affected and their weights were falling. Line A-A on Chart 1 marks the 105th day. Both then had distinct eye-symptoms such as haemorrhagic and congested eyelids, and photophobia. As indicated on the chart they were then given toheroa meal at the 2.0 gm. level for fourteen days. After a week on this the eyes were improved, and by the 9th day were quite cured. The weights increased and continued to rise for a fortnight after the dieting ceased. Then eye-symptoms recurred in one about the 145th day and she died when 167 days old. The other showed slight eye-symptoms about the same time as the other, but lived to the 190th day—the end of her growth curve is not shown on the chart.

Group Al, I, consisted of a buck and doe. Both developed eye-symptoms earlier than Al, II. They were given toheroa at the 1.0 gm. level, but the treatment was begun too late in the case of the buck, and he died four days after the treatment began. The doe gained weight (26 gm.) and the eye-symptoms cleared up. She was shown at a medical congress and died two days later, probably from pneumonia.

Group Al, III, consisted of two does. They had a history of loss of weight and eye-trouble very like that of Al, I and II. They were given 0.5 gm. toheroa each, and showed an increase in weight (20 gms. in one, 14 gms. in the other) with cure of eye-symptoms which had been well marked in one, but only slight in the other. Unfortunately, they had to be shifted to new quarters during the experiment, and both died soon afterwards. Their weight curves resemble

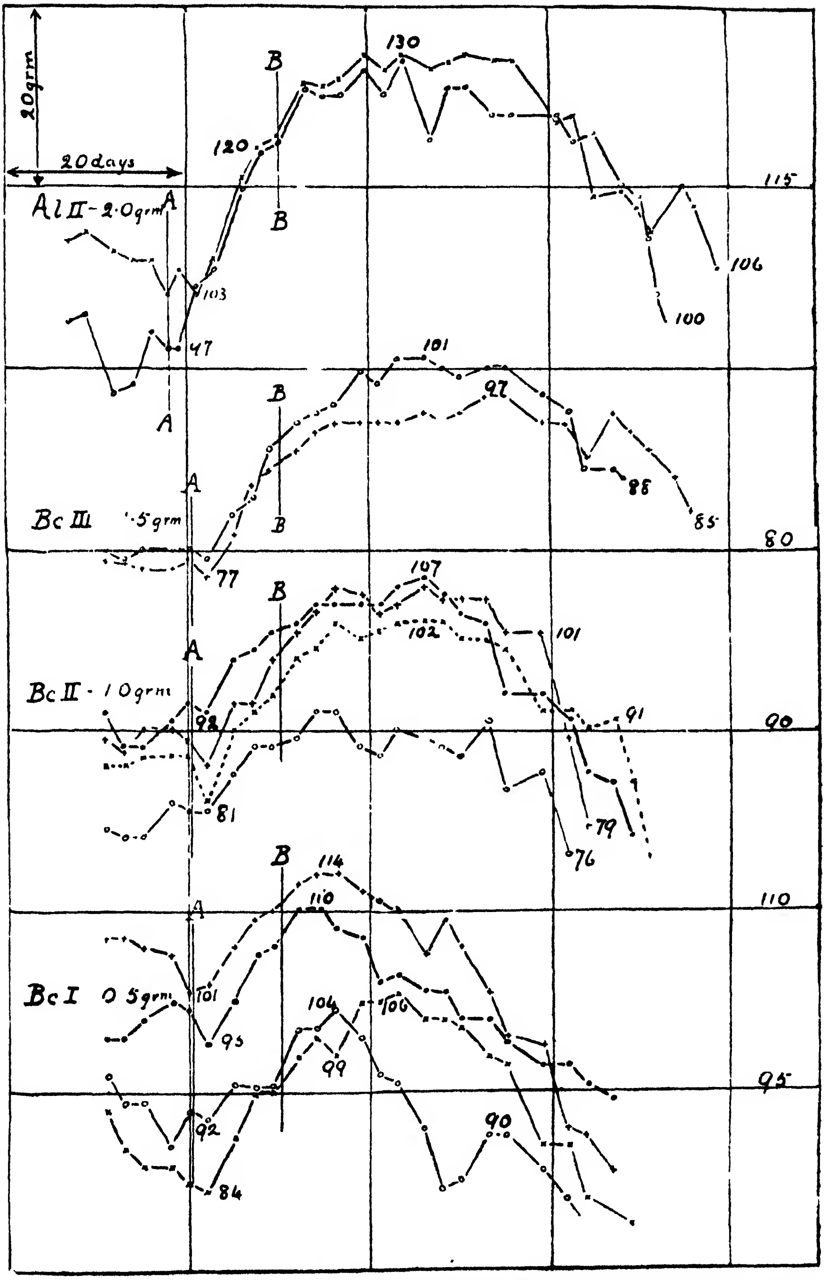


CHART 1.—Effects of adding different amounts of tinned toheroa daily during period A to B.

that of Bc, I, in Chart 1, in that the increase was not well maintained after dieting ceased.

Litter Bc consisted of ten rats. They were given basal diet when 20 days old, and were weaned on the 28th day, and divided into groups, viz.:—Bc I, four bucks; Bc II, four does; Bc III, two does.

During the ninth week after weaning, they began to show eye-symptoms and to lose weight. Line A-A (Chart 1) indicates the 90th day of age for this litter. All the groups were then at a suitable stage for commencing the toheroa diet, and in each case it was continued for ten days, to line B-B in the chart.

Bc, I: The four growth-curves of this group were so close together that, for the sake of clearness, the two lower ones on the chart have been dropped uniformly 5 grm. The dose here was equivalent to 0.5 grm. tinned toheroa to each rat. By the end of six days the eyes had greatly improved and the weights had increased. A few days after the toheroa diet was stopped they seemed perfectly normal in every way, but within another fortnight the eye-symptoms returned, the weights fell and they died at 138, 140, 143, and 145 days old.

Bc, II — received 1.0 grm each: In this case the eye-symptoms cleared up in the ten days of special dieting and the weights rose rapidly. They continued to grow or maintain their weight for about three weeks after the dieting ceased, then eye-symptoms returned while they were still apparently well, and then the weights began to decrease till they died or were killed at the following ages in days: 147, 149, 150, 152 (K).

Bc, III—received 1.5 gm. each: In these two doe rats the eye-symptoms, which were marked in one, slight in the other, improved and disappeared almost simultaneously with those of Bc II. Their weight increased more and was better maintained than in the case of Bc, II, but on the whole the difference does not seem to be proportional to the difference in dosage. This probably means that nearly the maximal amount of storage took place when 1.0 gm. was given. The rat that originally showed only slight eye-symptoms died without developing any more eye-trouble—the other had a recurrence. They died at 138 and 144 days. The tin of toheroa used for litter Al was several years old, that used for Bc was at least one year old.

Tiki-Toheroa Medicinal Broth.

This material as its name indicates is a concentrated toheroa soup. It was made into a meal and used in the same way as described for the whole toheroa, but in order to make a comparison the composition of the meal was so arranged that it had the same amount of toheroa solids as in the other case. Only one litter (Bd) was used, the growth curves of which are shown on Chart 2.

This litter consisted of five rats and was divided into two groups: Bd, I, two bucks; and Bd, II, three does. Basal diet began on the 20th day, and they were weaned on the 32nd day. By the end of six weeks from weaning the weights were stationary and eye-symptoms had begun in the form of congested zones round the eyes with haemor-

rhagic secretion, and photophobia. The toheroa soup-ration was then given for ten days beginning at A-A in Chart 2 when the rats were 74 days old.

Bd, I, received the equivalent of 1.0 gm. toheroa, and showed rapid improvement in eyes, in weights, and in general health. In a fortnight after commencing the toheroa soup, the eyes would pass

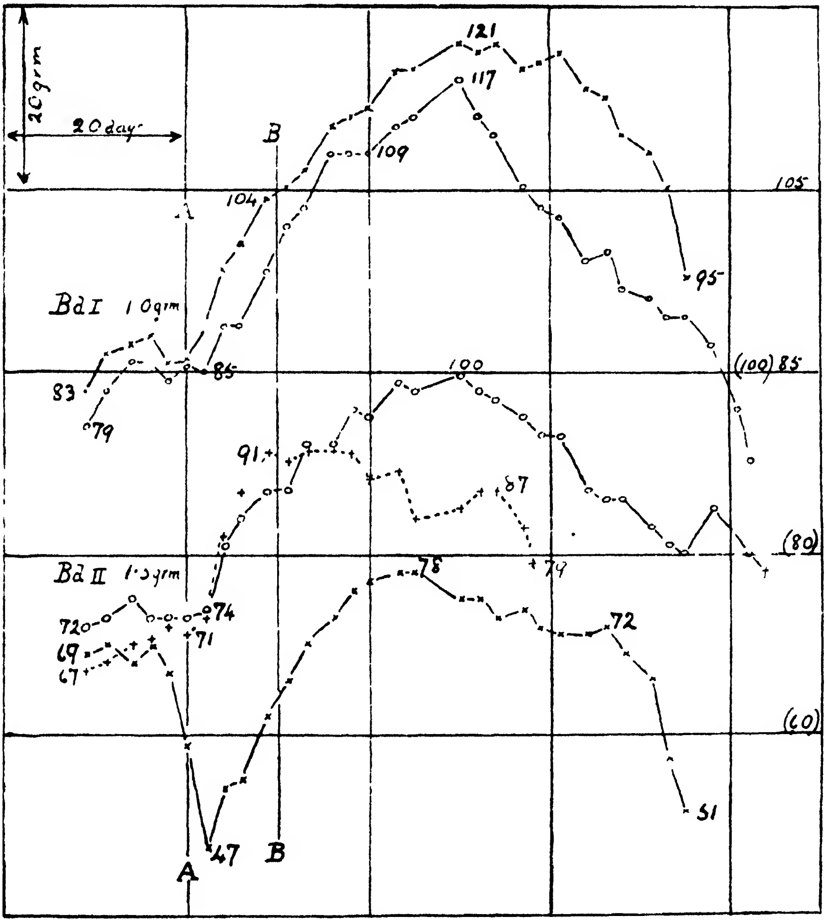


CHART 2.—Effects of adding different amounts of tinned toheroa soup during period A to B.

for normal, and the animals were plump and lively, but two weeks later the eye-symptoms recurred and the weights fell. They died with typical symptoms of avitaminosis at 130 and 137 days.

Bd, II, received 1.5 gm. and showed similar recovery of eye-symptoms and growth. One of the three made quite a remarkable recovery from what seemed a hopeless condition. The effect on the

growth-curves of this group seems less than in the case of Bd, I, which received the smaller dose, but this is probably due in part to the difference in the sexes, Bd I being bucks, and Bd II, does. These rats died at 113, 130, and 137 days. Unfortunately, circumstances did not allow of a further test with smaller quantities of this material.

Discussion and Conclusions.

From the earlier work on vitamins, tinned foods in general have been somewhat hastily judged to be deficient in all vitamins. In regard to vitamin-A the truth appears to be that, if the material is rich in this vitamin, the canned product still retains much—one would hesitate to say all—of the vitamin originally present. The experiments described above certainly indicate that toheroa when tinned whole, or even when made into a soup and then tinned, can supply as much vitamin-A as the rat can utilize when fed at the level of 1.0 to 2.0 gm. daily; even 0.5 gm. produces good results. While these experiments were in progress similar work was being done on Stewart Island oysters, both fresh and tinned, and, on the whole, the toheroas were the richer of the two, although both are valuable sources of vitamin-A. This may be related to the richer content in chlorophyll in the case of toheroa, and may indicate more of a phytoplankton diet as compared with a more zoöplankton diet for the oyster.

The writer again begs to acknowledge with thanks the financial aid of a grant from the New Zealand Institute: thanks are also due to Miss Earland for her services in attending to the rats.

References.

(1) Mestayer, M. K., *N.Z. Journ. of Sc. and Tech.*, 1921, vol. 4, p. 84.

(2) Storms, L. B., *Trans. N.Z. Inst.*, 1927, vol. 58, p. 264. (Recent methods are referred to in this paper.)

Otoliths of Fishes from the Tertiary Formations of New Zealand, and from Balcombe Bay, Victoria.

By G. ALLAN FROST, F.L.S., F.G.S., F.Z.S.

Communicated by H. J. Finlay, D.Sc.

[*Read before the Otago Institute, 6th December, 1927; received by Editor 22nd December, 1927; issued separately, May 17th, 1928.*]

THE following is a description of a collection of fossil otoliths, received from Dr. H. J. Finlay, of the University of Otago, to whom I am also indebted for a list of the formations in their proper sequence, and the estimated ages of the beds from which they were obtained. These are as follows:—

OTOTARAN.	Oligocene.
Waikaia.	
Wharekuri.	
Clifden (bands 4 and 6).	(? Probably basal Hutchinsonian.)
HUTCHINSONIAN.	Oligocene or lower Miocene.
Clifden (band 7).	
Otiake.	
LOWER AWAMOAN	Miocene.
Clifden (band 8)	
Target Gully.	
Ardgowan.	
UPPER AWAMOAN	Miocene.
Awamoa.	
Pukeuri.	
Rifle Butts.	

There are 5 new forms of otoliths, of which 4 belong to the family Congridae, and one is referred to the Cottidae; there is a good example of *Elops miocaenicus* Frost, and eleven other species from New Zealand and two from Victoria, corresponding with forms which have been described from the tertiaries of Europe.

As has been previously pointed out, the value of fish-remains from a stratigraphical point is necessarily slight, and this is especially so in the case of otoliths, owing to the persistence of the separate forms throughout the different epochs. It is, however, of interest to note that of the eleven species corresponding with European tertiary forms, only 1 has been described from the Pliocene, 7 from the Miocene, 4 from Oligocene formations, and 1 only from the Eocene.

The accompanying chart shows the formations in the ascending scale, the occurrence of species now described is indicated by a cross, and if figured in a previous paper by a double cross.

STRATIGRAPHICAL ARRANGEMENT, SHOWING INCIDENCE OF OCCURRENCE.

Age	Oligocene or Lower Miocene					Miocene			Miocene		
Formation	Ototaran			Hutchinsonian		Lower Awamoan			Upper Awamoan		
Locality	Waikaia	Wharekuri	Clifden Bands 4 & 6 4B 6A 6C	Clifden Band 7	Otiake	Clifden Band 8	Target Gully	Ardgowan	Awamoa	Pukeuri	Rifle Butts
Fig. 1	..	+	+	...	+	...	...	...	...	...	...
,, 2	...	...	+ +	+	+	...	...	...	...	...	...
,, 3	. .	...	+	...	...	...	...	..	...	...	...
,, 4	...	...	+	...	..	...	...	...	...	...	...
,, 5, 6 ...	∓	+	. .	...	..	...	...	∓ +	...	∓	...
,, 8	...	...	+ +	...	...	...	...	...	...	...	...
,, 9	...	...	+	...	+	...	. .	..	...	...	...
,, 10	...	...	. .	..	. .	...	+	...	...	...	...
,, 11	...	...	...	...	...	..	...	+	...	...	...
,, 12	...	...	...	...	+	...	...	...	...	...	...
,, 13	...	.	...	...	...	...	. .	+	...	...	...
,, 14	...	...	...	. .	...	...	+	...	...	...	...
,, 15	...	...	+	...	...	..	...	...	...	∓	...
Previously described:											
Scopelus sulcatus .	...	...	...	+	...	..	∓	∓	∓	∓ (also from Tuhna & White Rock River)	
Macrurus toulai ...	...	...	...	...	...	..	∓	∓	∓	∓	+
Pagellus gregarius ..	∓	+	∓	.	...	...	...	...	...	...	...
Fierasfer nuntius ...	∓	...	+ +	...	+	...	..	...	...	...	...

+ Now described.

∓ Previously described.

Otolithus (Congeris) wharekuriensis n. sp. (Fig. 1.)

Description.—Dimensions 9 × 6 mm. Shape elliptical, biconvex, dorsal rim domed, ventral rim curved, posterior rim pointed, anterior rim rounded. Sulcus wide, undivided, oblique, open on anterior part of dorsal rim, cauda with rounded end, does not approach posterior rim.

Material.—16 examples Wharekuri, 3 ex. Clifden, band 6a, 6 ex. Otiake.

Distribution.—Lower Miocene or Oligocene of Wharekuri and Clifden.

Remarks.—Resembles *Otolithus congeris papointi* Priem described from the Eocene (Ypresian) of Herouval, France (*Bull. Soc. Geol. de France*, vol. 6, p. 274, 1906). It differs in the more elongated shape, in the undivided lower line of the sulcus, and in the pointed posterior rim.

Otolithus (Congeris) rectus n. sp (Fig. 2.)

Description.—Dimensions 6 mm. × 3½ mm. Shape ovate, elongate, biconvex, dorsal rim low, straight, forms rounded angle with the oblique anterior rim; ventral rim curved, posterior and anterior rims obtusely pointed. Sulcus oblique, undivided, open on anterior part of dorsal rim.

Material.—2 ex. Otiake, 1 ex. Clifden band 4B, 4 ex. Clifden band 6C, 1 ex. Clifden band 7B.

Distribution.—Lower Miocene or Oligocene of Otiake and Clifden.

Remarks.—This species resembles *Otolithus* (*Congeris*) *wharekurensis* in the sulcus; it differs in the low straight dorsal rim and in the posterior rim. The shape is more elongated, and the posterior of the otolith is narrower than the anterior part.

Otolithus (Congridarum) clifdenensis n. sp. (Fig. 3.)

Description.—Dimensions 7 mm. × 5 mm. Shape irregular, highest anteriorly, biconvex, dorsal rim flat medially, oblique in its anterior and posterior parts, ventral rim deeply keeled anteriorly, oblique posteriorly, posterior rim obtuse, anterior rim oblique, with blunt angle. Sulcus straight, parallel with middle of dorsal rim, ends near the centre, ostial part shallow and ill defined.

Material.—The holotype, Clifden, band 6A.

Distribution.—Lower Miocene or Oligocene of Clifden, New Zealand.

Remarks.—The shape of the otolith resembles that of the recent genus *Congermuraena* in the anterior depth of the ventral rim; it differs in the dorsal rim, also in the sulcus which is similar to that of *Uroconger*.

Otolithus (Congridarum) ornatus n. sp. (Fig 4.)

Description.—Dimensions 4 mm. × 2½ mm. Shape ovate, biconvex, dorsal rim low, irregular, ventral rim keeled anteriorly, posterior and anterior rim bluntly pointed, with praesulcal area; sulcus broad, curved and short, ostium distended and enclosed anteriorly, with narrow opening to anterior part of dorsal rim. A band extends from the ostium along the ventral and posterior rims.

Material.—The unique holotype from Clifden, band 6A.

Distribution.—Lower Miocene or Oligocene of Clifden, New Zealand.

Remarks.—Resembles the otoliths of *Otolithus* (*Congeris*) *wharekuriensis* in general; it differs in the irregularity of the rims, especially in the anterior depth of the ventral rim, also in the curved sulcus and in the praesulcal area.

Otolithus (Dentex) aff. subnobilis Sch. (Figs. 5, 6.)

Description.—Dimensions 3½ mm. × 2½ mm. Shape ovate, sulcus straight, ostium small. cauda long, pointed, does not reach posterior rim.

Material.—3 ex. Wharekuri, 1 ex. Ardgowan.

Distribution. — Lower Miocene or Oligocene of Wharekuri, Miocene of Ardgowan.

Remarks.—Described by Schubert from the tertiaries of Austro-Hungary (*Jahrb. der K.K. Geol. Reichsanst,* vol. 56, p. 263, 1906). Also by Priem from the Miocene (Burdigalien) of Martillac and Leognan, S.W., of France (*Bull. Soc. Geol. de France*, vol. 14, p. 263, 264, 1914), and from Waikaia, Ardgowan, and Pukeuri, New Zealand, by Frost (*Transactions of the New Zealand Institute*, vol. 55, p. 613, 1924).

Otolithus (Monocentris) Lemoinei Priem (Figs. 7, 7a.)

Description.—Dimensions 9 mm. × 7 mm., 8 mm. × 7 mm.

Material.—3 large examples.

Distribution.—Eocene of Balcombe Bay, Victoria.

Remarks.—Described from the Eocene of Reims by Maurice Leriche (*Ann. Soc. Geol. du Nord*, Tome 37, p. 246; Pl. 6, figs. 7, 7a, 8, Lille, 1908).

Otolithus (Percidarum) plebejus Koken. (Fig. 8.)

Description.—Dimensions 4 mm. × 2½ mm.

Material.—2 examples Clifden band 6A; 6 examples Clifden band 6C.

Distribution. — Lower Miocene or Oligocene of Clifden, New Zealand.

Remarks.—Described by Koken from the Middle Oligocene of Waldbockelheim. (*Zeit. d. deut. Geol. Gesell.*, Bd. 43; Taf. 10, Fig. 1).

Otolithus (Percidarum) frequens Koken. (Fig. 9.)

Description.—Dimensions 4 mm. × 3½ mm.

Material.—5 examples Otiake; 6 examples Clifden, band 6C.

Distribution.—Lower Miocene or Oligocene of Otiake and Clifden, New Zealand.

Remarks.—Described by Koken from the upper Oligocene of Sternberger Gestein (*Zeit. d. deut. Geol. Gesell.*, Bd. 43; Taf. 8, Fig. 4).

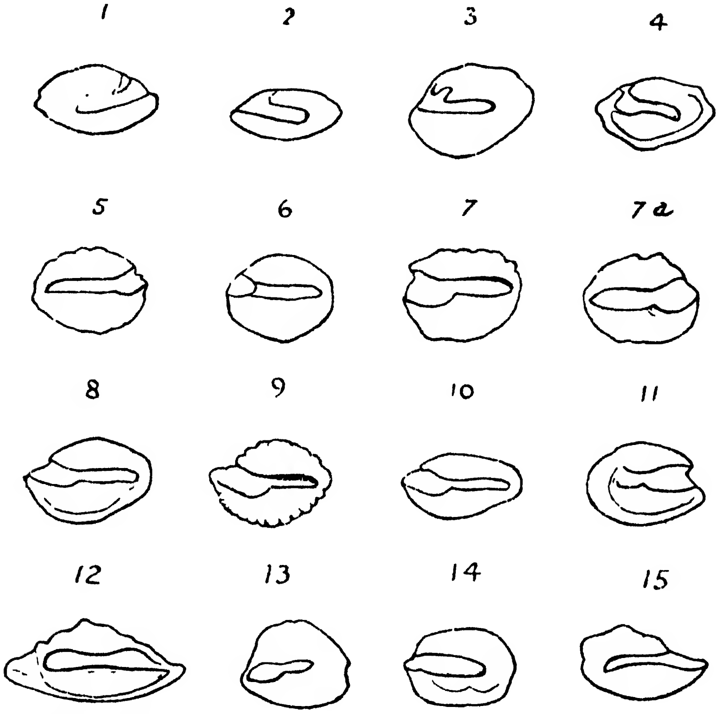
Otolithus (Percidarum) aff. augustus Priem. (Fig. 10.)

Description.—Dimensions 3½ mm. × 2 mm.

Material.—1 example.

Distribution.—Miocene of Target Gully, New Zealand.

Remarks.—Described by Priem from the Lutetien (Middle Eocene) of Le Bois-Gouet, Loire Inférieure (*Bull. Soc. géol. de France*, vol. 13, p. 155; fig. 7, 1913).



G. Allan Frost del.

FIG. 1.—*Otolithus* (*Congeris*) *wharekuriensis* n. sp. × 2.
FIG. 2.—*Otolithus* (*Congeris*) *rectus* n. sp. × 2½.
FIG. 3.—*Otolithus* (*Congridarum*) *clifdenensis* n. sp. × 2½.
FIG. 4.—*Otolithus* (*Congridarum*) *ornatus* n. sp. × 4.
FIGS. 5, 6.—*Otolithus* (*Dentex*) aff. *subnobilis* Schubert. × 4½.
FIGS. 7, 7a.—*Otolithus* (*Monocentris*) *Lemoinei* Priem. × 2.
FIG. 8.—*Otolithus* (*Percidarum*) *plebejus* Koken. × 4.
FIG. 9.—*Otolithus* (*Percidarum*) *frequens* Koken. × 4.
FIG. 10.—*Otolithus* (*Percidarum*) aff. *augustus* Priem. × 4½.
FIG. 11.—*Otolithus* (*Scopelus*) *pulcher* Prochazka. ×4½.
FIG. 12.—*Otolithus* (*Cottus*) *otiakensis* n. sp. × 8.
FIG. 13.—*Otolithus* (*Pleuronectidarum*) *splendens* Schubert. × 6.
FIG. 14.—*Otolithus* (*Solea*) *Kokeni* Bass & Schubert. × 7.
FIG. 15.—*Otolithus* (*Elops*) *miocaenicus* Frost. × 3½.

Otolithus (Scopelus) pulcher Prochazka. (Fig. 11.)

Description.—Dimensions 3½ mm. × 2 mm.

Material.—2 examples.

Distribution.—Miocene of Ardgowan, New Zealand.

Remarks.—Described by Prochazka from the Miocene of Seelowitz in Mahren (*Sitzungsber d. bohm. Franz-Joseph Akad.*, 24, Prag. 1893), by Priem from the Pliocene of d'Aleria, Corsica (*Bull. Soc. geol. de France*, vol. 11, 1911), and by Bassoli from the Miocene of Monte Gibio, Italy (*Riv. Ital. di Paleont.*, Anno 12, Fasc 1, p. 50, Perugia, 1906).

Otolithus (Scopelus) sulcatus Prochazka.

2 examples from the Hutchinsonian of Clifden, examples described by the author from Tuhna, North Island, Pukeuri, Awamoa, White Rock River, Ardgowan, Target Gully (*Trans. New Zealand., Inst.*, vol. 55, p. 607, 1924).

Otolithus (Maxrurus) toulai Schubert.

3 examples from the Miocene (Awamoan) of Rifle Butts; I example from Ardgowan; 1 example from the Eocene of Balcombe Bay, Victoria.

Previously described by the author from Pukeuri, Awamoa, Ardgowan, Target Gully (*ibid*, p. 608).

Otolithus (Cottus) otiakensis n. sp. (Fig. 12.)

Description.—Dimensions 3 mm. × 1½ mm. Shape elongate, outer side concave, inner side convex, dorsal rim serrated, highest medially; ventral rim curved, posterior rim short, vertical; anterior rim pointed, rostrum, no antirostrum or excisura. Sulcus biovate enclosed, with median constriction. Rostrum, posterior area, and band above ventral rim, lower than the central area ot the inner side.

Material.—3 examples including holotype.

Distribution.—Lower Miocene or Oligocene of Otiake, New Zealand.

Remarks.—This otolith resembles the sagitta of the recent species *Cottus gobio* of the family Cottidae, the outline being identical, and the sulcus very similar.

Otolithus (Pleuronectidarum) splendens Schubert. (Fig. 13.)

Description.—Dimensions 2½ mm. × 2½ mm.

Material.—1 example.

Distribution.—Miocene of Ardgowan, New Zealand.

Remarks.—Described by Schubert from the Miocene of Voslau (*Jahrb der K.K. Geol. Reichsanst*, 56, p. 263, Wien., 1906).

Otolithus (Solea) Kokeni Bass and Schubert. (Fig. 14.)

Description.—Dimensions 2 mm. × 1½ mm.

Material.—1 example.

Distribution.—Miocene of Target Gully, New Zealand.

Remarks.—Described by Bassolo, from the Middle Miocene of Monte Gibio, Modena. (*Riv. Ital. di Paleont.*, Anno 12, Fasc 1, p. 45; Tav. 11, Fig. 3, Perugia, 1906).

Otolithus (Elops) miocaenicus Frost. (Fig. 15.)

Description.—Dimensions 5 mm. × 2½ mm.

Material.—1 example.

Distribution.—Lower Miocene or Oligocene of Clifden, band 6 C, New Zealand.

Remarks.—Described by the author from the Miocene of Pukeuri. New Zealand (*Trans. New Zealand Inst.*, vol. 55, p. 612, 1924).

Otolithus (Pagellus) gregarius Koken.

Material.—3 examples from the Oamaru series of Wharekuri.

Remarks.—Examples previously described from Waikaia and Clifden (*Trans. New Zealand Inst.*, vol. 55, p. 613, 1924). First figured by Koken from the Upper Oligocene of Sternberger Gestein (*Zeit der deut Geol. Gesell.*, vol. 43, Taf. 7, Figs. 7, 7a), also noted by Priem from the Miocene (Burdigalien) of South West France (*Bull. Soc. geol. de France*, 4th series, tome 45, p. 266, 1914).

Otolithus (Fierasfer) nuntius Koken.

7 examples from Clifden, bands 6C, and 6A, and 3 from Otiake (Lower Miocene or Oligocene). Previously described from the Oamaru series of Waikaia (*ibid*, p 611), also by Koken from the Middle Oligocene of Sollingen (*Zeit du deut Geol. Gessell.*, Bd. 43; Taf. 6, Figs. 2, 2a.).

Pillow-Lavas, Peridotites and Associated Rocks of Northernmost New Zealand.

By J. A. Bartrum, Auckland University College, and F. J. Turner, Otago University.

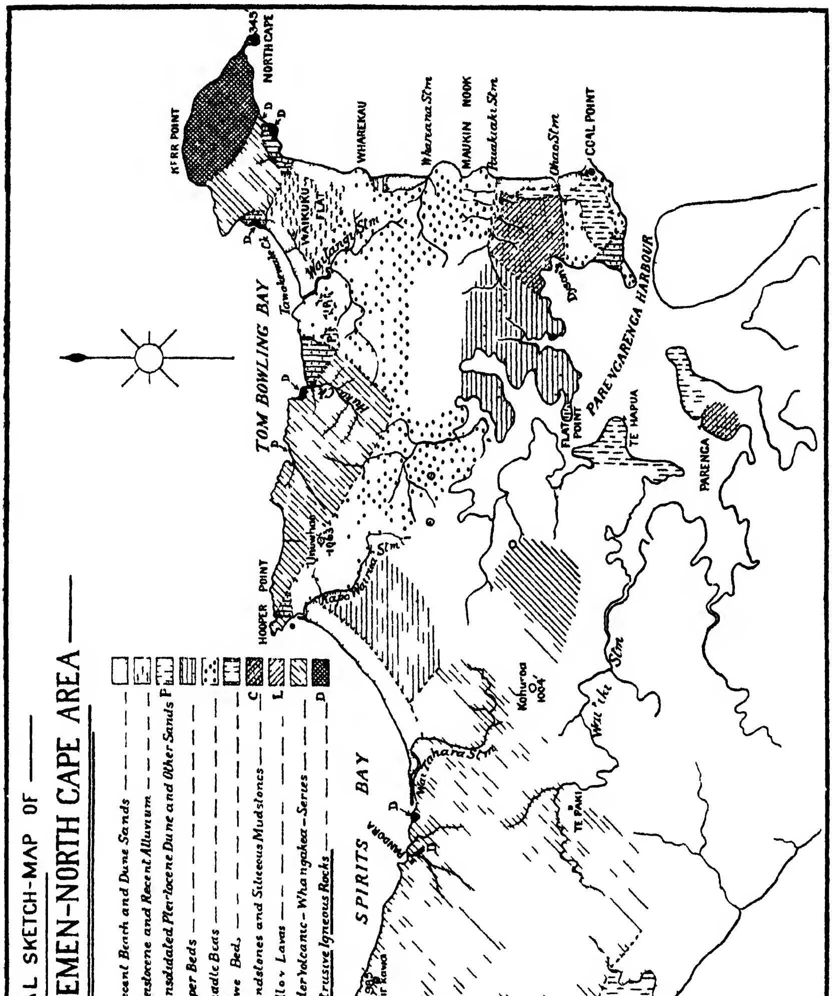
[Read before the Auckland Institute, 4th October, 1927; received by Editor, 22nd December, 1927; issued separately, May 19th, 1928.]

(Plates 20—24.)

Contents.

Introduction.

The authors recently visited the Cape Maria van Diemen—North Cape area of New Zealand with the primary object of studying the peridotites and gabbroid rocks described from there by Bell and Clarke (1910). Owing to the time available being limited, and to


GEOLOGICAL SKETCH-MAP OF
CAPE MARIA v DIEMEN-NORTH CAPE AREA
LEGEND
RECENT AND PLEISTOCE
Recent Beach and Dune Sands
Pleistocene and Recent Alluvium
Consolidated Pleistocene Dune and Other Sands
? MIOCENE COAL POINT SERIES
Upper Beds
Middle Beds
Lower Beds
UP. CRETACEOUS
Sandstones and Siliceous Mudstones
RAHIA SERIES
Pillow Lavas
? TRIAS-JURA
Older Volcanic - Whangakea - Series
Intrusive Igneous Rocks
SCALE
Miles
Geology by J A Bartrum and F J Turner
Geological Boundaries Approximate
KERR POINT
NORTH CAPE
WHAREKAU
MAUKIN NOOK
COAL POINT
TOM BOWLING BAY
WAIKUKU FLAT
PAREngarenga HARBOUR
FLAT POINT
TE HAPUA
PARENGA
HOOPER POINT
SPIRITS BAY
PANDORA
TE PAKI
CAPE REINGA
TWILIGHT BAY
SCOTT POINT
CAPE MARIA VAN DIEMEN

the fact that a considerable portion of it was not used to best advantage because the coastal exposures could not be visited during higher phases of the tide, the survey was very far from being thorough. In spite of this fact, however, the observations made have brought to light interesting information, and have shown that erroneous ideas have long been allowed to persist regarding the nature of many of the rocks of the area.

This paper has therefore been prepared in order to remove these misconceptions, and to introduce several fresh facts which have an important bearing upon the geology of this northern region. The authors regret that, owing to force of circumstances, they have had to leave unvisited localities which, judged by the reports of McKay (1894), and Bell and Clarke (1910), would certainly have well repaid investigation. Their thanks are due to Mr. and Mrs. L. Keene, of Te Paki Station, who gave every assistance and kindness within their power, to Mr. H. MacQuarrie for kindly collecting and forwarding rocks from Pandora, to Mr. Manihera, who proved a veritable mine of reliable information regarding routes, and finally to their companions, Messrs. W. E. La Roche and K. A. Allen, who gave valuable help in field work.

Through the courtesy of the late Mr. P. G. Morgan, for many years Director of the New Zealand Geological Survey, several excellent analyses by Mr. F. T. Seelye, of the Dominion Laboratory, are available to support petrographic descriptions of certain igneous rocks.

The authors of this paper would like to place on record their great appreciation of the unfailing assistance which Mr. Morgan has always afforded whenever it lay in his power. His interest and co-operation have been of incalculable benefit to the advancement of geology in this country.

Earlier Work.

The only important reports upon the geology of the North Cape—Cape Maria van Diemen area are those of McKay (1894), Bell and Clarke (1910), and Bell (1909), though Hector visited the district prior to McKay, for it is mapped in his geological maps of New Zealand, and its geology briefly mentioned in an early report (1872), whilst Dieffenbach (1843, p. 199) has made mention of it in his *Travels in New Zealand.* Park (1910), Marshall (1911, 1912), and Morgan (1921) have issued geological maps of the area now described, and with others, such as Bartrum (1925), have made brief reference to certain features of its geology, but have depended for their information entirely upon the work of McKay, Hector, and Bell and Clarke.

Synopsis of Stratigraphy.

The papers of McKay (1894), and Bell and Clarke (1910) have described the present terrain as underlain by sediments of the comprehensive mid-Mesozoic system now known as the Hokonui System. McKay noted that these were invaded by masses of crystalline igneous rocks, and Bell and Clarke added the interesting facts that amongst

these latter there were varied series of ultrabasic and gabbroid rocks, whilst amygdaloidal and other igneous rocks intermixed in the so-called sediments were probably contemporaneous lavas (Bell, 1911).

The identification of the rocks in question as sediments of the Hokonui system is erroneous, for they prove to be shattered and locally crushed basic andesitic and basaltic rocks of varied type which include pillow-lavas with which, as is expectable, some marine sediments are bedded. The nearest sediments of Hokonui facies appear to be those at Te Arai Bluff on the west coast, which is over 20 miles south of North Cape. It must be admitted, however, that Bell and Clarke (1910), whilst accepting McKay's designation of the rocks as sediments, appear to have had considerable doubt in their minds as to the correctness of this course.

As will be shown, though many reasons can be advanced for regarding this series of igneous rocks (Whangakea Series of Bell and Clarke, 1910) as mid-Mesozoic (Hokonui System) in age, it may well be uppermost Cretaceous or Palaeocene, for marls laid down in close association with pillow-lavas at Pandora (Whangakea), Spirits Bay, contain numerous tests of foraminifera, amongst which there is a form closely resembling *Orbulina.* These volcanic rocks are the oldest rocks of the Cape Maria van Diemen—North Cape District, and are provisionally classed as contemporaneous flows of the Hokonui System (Trias —? Neocomian) analogous to those of the Whangaroa area (Bell and Clarke, 1909). During the orogeny which terminated Hokonui sedimentation immediately at the close of the Neocomian these flows were intensely shattered, and, probably also at this time, invaded by a mass of gabbroid and ultrabasic rocks in the vicinity of North Cape, for Benson (1920, 1926) has ably shown that ultrabasic intrusions are a characteristic accompaniment of moderately intense crustal compression, whilst, in addition, the intrusive gabbroid rocks include gneisses which are clearly the result of piezocrystallization. On the analogy of Andrews's interpretation of conditions at Broken Hill (1923a) these intrusive bodies probably form a sill-like mass which was injected under considerable pressure. In addition to this major intrusion, there were smaller probably contemporaneous ones of intermediate character. These did not, however, close the cycle of igneous activity, for intrusions in the form of dykes and sills cut mid-Tertiary sediments (Coal Point Series), whilst interbedded with these latter, there are thick masses of andesitic conglomerates and tuff which are products of a phase of vulcanicity which manifested itself far and wide in the northern half of the North Island at this time.

Evidence from other parts of New Zealand clearly demonstrates that the post-Hokonui diastrophism was followed by prolonged erosion prior to the deposition of succeeding Upper Cretaceous beds. These are represented in the present area by steeply folded sediments (Rahia Series of Bell and Clarke) which contain occasional fragments of a large fibrous corrugated shell referable with tolerable certainty to *Inoceramus.* They are the equivalent of the Kaeo Series or Whangaroa (Bell and Clarke, 1909) and probably also of the Otamatea Beds described by Ferrar (1924) from Kaipara Harbour. Unfortunately, the contact of these Cretaceous beds with over-lying strata

was not observed by the writers, but many facts indicate that a minor period of pressure, with accompanying emergence and ensuing erosion, intervened between the date of deposition of these strata and that of a varied series of mid-Tertiary sediments (Coal Point Series of Bell and Clarke) which were their immediate successors. These latter strata frequently rest unconformably upon a basement of the Older Volcanic (Whangakea) rocks. At their base there is a conglomerate, which is followed by marine sandstones, then by andesitic conglomerates spread in an extensive sheet at least 600 ft. in thickness, and finally by an upper thick deposit of marine sandstones.

The emergence of these mid-Tertiary beds above the shallow seas in which they accumulated was accompanied by the faulting characteristic throughout New Zealand of this post-Miocene (Kaikoura) orogenic phase. Powerful faults which perhaps passed locally into monoclinal folds, as has happened elsewhere in New Zealand, differentially elevated various blocks of the terrain, which were peneplained after prolonged erosion. This erosion removed great thicknesses of strata from the more elevated blocks and laid bare the peridotites and gneissic gabbros near North Cape. Plateau-like remnants of the peneplain are to-day the most remarkable physiographic feature of the eastern portion of the area described in this paper.

Though incapable of demonstration, it is probable that the uplift mainly responsible for the modern elevation of the plateaus has been accompanied by further differential movement along lines of weakness marked out in the earlier stage, for Waikuku Flat, west of North Cape, is more readily explained as the site of a relatively depressed block than as the sole result of selective erosion following eustatic uplift. This final uplift was considerably greater quantitatively than the present height (between 500 ft. and 600 ft.) of the remnants of the ancient peneplain, for it has been followed by a sub-Recent negative movement of the area which has allowed drowning of the lower portions of many of the streams.

The most recent change of sea-level relative to the land has accompanied a positive movement of about 5 ft. which is demonstrated by raised beaches along many of the coasts of North Auckland, as was early pointed out by Percy Smith (1881).

Long subsequent to the emergence of the North Cape—Cape Maria van Diemen area at the close of Miocene deposition (Coal Point Series), extensive deposits of wind-blown sand accumulated, and to-day Pleistocene and Recent dune-sands here and there mask the elder rocks of the coasts.

Physiography.

For completeness of description it has been considered advisable to give a brief account of the physiography of the district now studied, although this has already been well described by Bell and Clarke (1910).

The greater part of the area between Cape Maria van Diemen and North Cape consists of a maturely dissected upland the highest points of which attain a height of a little over 1,000 ft. On the north it is abruptly terminated by the rugged northern coast, but south it

merges into a great tombolo which continues south-east for fifty or sixty miles to the ancient mainland at Ahipara.

The drainage pattern is mainly insequent, for the streams show little dependence upon the structure of the area. These latter generally are approaching grade, for they often have swampy valley-floors or else meander over small alluvial flats in their lower reaches. Nevertheless, many of the tributary streams are far from mature and are broken here and there by waterfalls, whilst their valley slopes are generally very steep. Again, although the divides have usually the well-defined nature and softened slopes characteristic of maturity, remnants of an elevated plain of erosion persist at a height of from 500 ft. to 600 ft., and form a very conspicuous feature of the topography, especially in the vicinity of North Cape.

A further element in the topography has been introduced, particularly in the south-west, by the accumulation during Pleistocene and Recent times of great areas of wind-blown sand which are well developed in Tom Bowling, Spirits, and Twilight Bays. These dune-covered areas reach their maximum development south of the district under consideration, and have been described in detail by McKay (1894), and Bell and Clarke (1910). Erosion of consolidated ancient dune-sands by temporary streams draining into Twilight Bay has resulted in developing, near the north end of the bay, a splendid small-scale example of bad-land topography (see Fig. 4).

In contrast with the general insequent drainage, there are one or two instances of streams which have had their courses determined by lines of structure. Such instances will be considered in some detail, for they afford important physiographic evidence as to the structure of the area. The first example of such structural control is furnished at the east end of Spirits Bay, where the tributaries of Kapo Wairua Stream draining from the south-east have adjusted themselves parallel to the strike of a thick series of resistant volcanic conglomerates interbedded with much softer strata. A prominent N.W.—S.E. homoclinal divide (Fig. 6) has been carved from the conglomerate, having steep escarpment slopes on the north-east and somewhat gentler dip slopes on the south-west, whilst less pronounced but quite distinct series of similar cuesta-like divides may be observed in lowlands of soft sandstone west of Kapo Wairua Stream and immediately inland from Spirits Bay. West of these sandstone lowlands there are resistant volcanic rocks which constitute hills which rise abruptly to a height of 1,000 ft. The boundary of the two formations runs south-east from the west end of Spirits Bay beach, and both physiographic and stratigraphic evidence point to this junction being determined by faulting.

There is a second example of subsequent drainage about two miles east of Cape Reinga where the north-west line followed by Otangawhiti Stream is continued beyond its headwaters by a tributary of Taputaputa Stream. Just below its confluence with this tributary, Taputaputa Stream swings around in a semi-circle and flows north-west to the shore. The physiography thus points very strongly to the presence of a fault-zone running in a N.W.-S.E. direction up the valley of this tributary of Taputaputa Stream and down Otangawhiti Valley to the sea.

The facts also suggest that the main valley of Taputaputa Stream is incised along a similar N.W.-S.E. zone of shattering, whilst, going further afield, indubitable evidence of similar control is furnished by the valley of Huka Stream draining into the middle portion of Tom Bowling Bay, for the actual fault-plane is traceable at the shore.

Further physiographic evidence of faulting is afforded by a resistant block about 5 square miles in area of which North Cape forms the most easterly point. This North Cape block attains an altitude of about 750 ft., and is separated from highlands further south-west by a broad undulating flat about 40 ft. above sea-level known as Waikuku Flat, which is covered superficially by alluvium and swamp-filling, and is margined by sand-dunes.

The North Cape block rises so steeply from this flat as to suggest that its south-west face is a dissected fault or fault-line scarp, and, as will be seen from the section appearing later, there is corroborative stratigraphic evidence of a fault running N.W.-S.E. parallel to the north-east border of the lowland. Further south-west the topography again suggests that a fault may separate Waikuku Flat from plateau-like highlands further south-west; if this be so, the north-west trend of Waitangi Stream is subsequent upon such faulting.

This evidence of N.W.-S.E. fracturing is of especial interest in that it shows the continuation of dominant fractures having this trend, along with others roughly at right angles to the first, from as far south as Taupo, where they have been described by Henderson (1924). Bartrum and Laws (MS., 1924) have recognized the dominance of these series near Auckland, and Ferrar (1925, pp. 18-20) in the extensive Whangarei—Bay of Islands area, though Bell and Clarke (1909, p. 23) were able to recognize only an E.N.E.-W.S.W. series near Whangaroa.

The coast-lines of the Cape Maria van Diemen—North Cape district are still in a comparatively youthful stage of development, for they consist in general of rugged stretches, with sea-cliffs as much as 800 ft. in height, where slow retrogression is in progress, which alternate with long sandy bays backed by extensive dune areas which represent the partly filled embayments of the original coast-line of submergence. Probably the most striking feature of the coast-lines is the unusually perfect development of broad, flat, horizontal platforms carved at the base of the cliffs at the height of about 1 ft. above normal high-water level, and perhaps especially prominent in the resistant ancient volcanic rocks of the region. The origin of similar platforms has been discussed in detail by one of the writers (Bartrum, 1926), and need not further be considered here, beyond mentioning that they are believed to be due primarily to the action of storm-waves. These have most effective action at a level slightly above normal high-water level during higher phases of the tide. There appear to be grounds for the belief, however, that subaerial processes active upon the wave-cut platforms have contributed very materially to the remarkably level nature of the benches of the present area, more especially where they have been developed in more shattered rocks.

In contrast with the exposed northern and western coasts, that of Parengarenga Harbour presents outlines of a much less regular kind, for it has originated by submergence of a maturely sculptured

area in not far distant times, and, on its northern shores, its initial outlines have not been very greatly modified. Widespread mudflats are witness, however, to extensive infilling subsequent to the submergence, though the recession of the sea-cliffs at headlands does not appear to have been considerable.

The negative movement involved must be taken as the widespread one responsible for the unique embayed coast-lines of almost the whole of the eastern coast of North Auckland. Its amount cannot be calculated with any precision, but was probably about the order of 200 ft.

At a date subsequent to this, however, there have been slight elevatory movements. Broad stream terraces about 30 ft. above sea-level are extensively developed along the banks of Waitiki Stream. They are composed of relatively fine-textured alluvium and suggest that, during the period of aggradation which gave birth to the flood-plain from which they were carved, sea-level was distinctly higher than now. Other evidence of sub-Recent positive movement is afforded by beaches about 4 ft. above modern storm-beach level on the northern coast about three-quarters of a mile west of Waitangi Stream, whilst McKay (1894) describes broad flats of marine muds containing recent molluscan species which reach a height of from 10 ft. to 15 ft. above sea-level near the shores of Parengarenga Harbour. Sub-Recent uplift of similar amount can be observed in numerous other parts of North Auckland, especially around the shores of Waiheke Island, Brown Island, Ponui Island and the mainland in the vicinity of Auckland, and has already been remarked by writers such as Smith (1881), Henderson (1924a, p. 582), Ferrar (1925, pp. 53-54) and others. This uplift occurred long after the major submergence described above, at a time when the coast-lines had attained approximately their present outlines.

DETAILED STRATIGRAPHY.

The upward sequence of sedimentary and extrusive igneous rocks appears to be as follows:—

(1) Older Volcanic Series (Whangakea Series of Bell and Clarke)—age? Trias-Jura. Flows of basaltic rock with minor sediments.

(2) Upper Cretaceous Series (Rahia Series of Bell and Clarke). Siliceous mudstones and concretionary green sandstones with *Inoceramus*. Probably also includes basic pillow-lavas.

(3) Middle and Later Tertiary Series (Coal Point Series of Bell and Clarke).

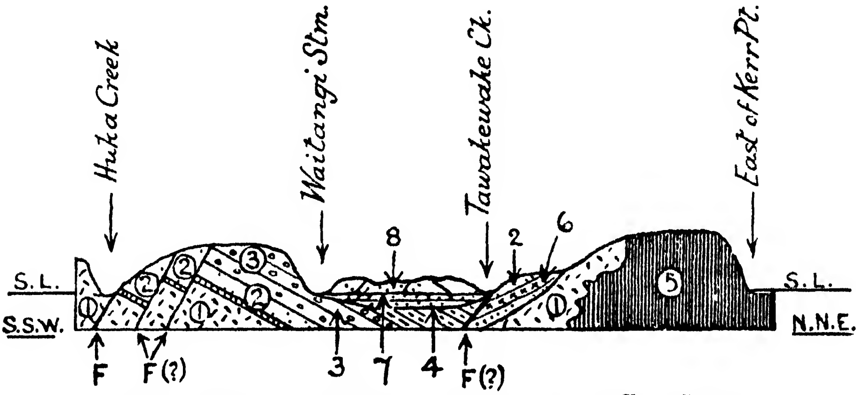
- (*a*) Lower Beds including sandstones, mudstones, tuffs and fossiliferous basal conglomerate;
- (*b*) Andesitic conglomerates;
- (*c*) Upper Beds including sparsely fossiliferous sandstones, mudstones, grits, and minor conglomerates.

(4) Recent and Pleistocene dune-sands, bedded silts and gravels.

1. Older Volcanic Series (Whangakea Series of Bell and Clarke).

Distribution and Lithology.

The name Whangakea Series was first used by Bell and Clarke (1910) to include the extensive series of rocks which is developed in hilly country extending west and south from Pandora (Whangakea) at the west end of Spirits Bay Beach, to Te Paki, Cape Maria van Diemen and Cape Reinga. The same writers also mapped similar rocks exposed along the western part of Tom Bowling Bay between Hooper Point and Huka Creek, as part of the same series, whilst McKay (1894) had previously described and mapped both these areas as comprised mainly of Older Secondary or Palaeozoic sediments. Numerous outcrops of the rocks of this series, which are here



Section S.S.W. and N.N.E. from Huka Creek to Kerr Point.

(1.) Older Volcanic Series. (2.) Lower Beds of Coal Pt. Series. (3.) Middle Beds (andesitic conglomerates) of Coal Pt. Series. (4.) Upper Beds of Coal Pt. Series. (5.) Basic and Ultrabasic intrusives of Kerr Pt. (6.) Sill of quartz diorite. (7.) Pleistocene bedded silts. (8) Pleistocene and Recent dune sands.

designated the Older Volcanic rocks, were also observed by the writers in valleys adjacent to the track from Te Paki to Te Hapua on the western shores of Parengarenga Harbour, so that these rocks evidently extend a considerable distance south-east from Pandora. A narrow strip of similar rocks was also found to connect the east and north coasts along the north-east margin of Waikuku Flat in the vicinity of North Cape, where they are invaded by a large mass of gabbroid and ultrabasic rocks.

The rocks of the Older Volcanic (Whangakea) Series consist of a succession of thick flows of basaltic or andesitic rocks which are intensely shattered, and in thin section show various effects of pressure, whilst, wherever individual flows are recognizable, they appear to be tilted at high angles. Although the main mass of the series consists of normal flows, pillow-lavas are developed in the vicinity of Pandora, and, less perfectly, at various places along the western part of Tom Bowling Bay.

McKay (1894) describes the rocks here recognized as volcanic types as mainly indurated sandstones, shales and slates of Palaeozoic or Older Secondary age which have been intruded by "crystalline rocks" near North Cape and elsewhere. He evidently mistook them

for older greywackes and other indurated sediments such as those of the Whangaroa district, which are now referred to the Waipapa Series (Hokonui System) of probable Trias-Jura age.

Marshall (1908, Pl. 13) maps these Older Volcanic rocks and the intrusives of North Cape as diorites and gabbros of uncertain age, presumably on the assumption that McKay made an error in identification similar to that which Marshall (*loc. cit.*, pp. 81-82) found that he made in the case of similar rocks in the Mongonui district. Bell and Clarke (1910), whilst recognizing that a large quantity of igneous material is present in the Whangakea Series, nevertheless follow McKay's opinion that the series is mainly sedimentary. The microscopic examination of a large number of thin slices representative of the rocks shows that they undoubtedly represent volcanic flows, even though in some localities intense shattering has induced close macroscopic resemblance to indurated sediments. The whole series appears to be volcanic with the exception of a small amount of sedimentary material associated with pillow-lavas at Pandora.

In this connection the section at this latter locality (Whangakea) at Spirits Bay is of especial interest. Almost vertical pillow-lavas are well developed at the extremity of a small headland immediately west of the mouth of the small stream at Pandora, and on a small stack a few yards off-shore from this point. With the pillow-lavas there are basaltic rocks lacking the pillow form and so intensely shattered and crushed that they closely resemble red and green clay-shales. Careful examination reveals, however, that cores of less crushed microscopically identifiable basalt persist in the general shale-like material and strongly suggest the volcanic origin of the whole series. In some places below the pillow-lavas, where the cores of basaltic rock are especially numerous, the rock resembles a conglomerate veined and cemented with calcite. A few yards south from the pillow-lavas towards the beach at Pandora, there is a dyke of pyroxene diorite (N.C. 2) which serves to complicate the section, and, still further on, there are striped red and green rocks which are associated with finely laminated compressed foraminiferal marls. The green material proves on sectioning to be andesitic in character, but the red with which it is intermixed in irregular lensoid manner, is probably sedimentary. The intermixture can be explained as a result of moderately acute shearing.

The pillow-lavas present the usual chilled crust and are almost certainly submarine flows, so that the associated sediments represent deposits formed during an interval between successive outpourings on the sea bottom.

East from Pandora there are two headlands composed mainly of normal older volcanic (Whangakea) rocks. At the second, however, there is an interbedded steeply dipping flow of pillow lava on the line of strike of the similar flow further west. As before, the rocks below the pillow-lava are severely crushed. Still further east at the same headland, there is a mass of hyalopilitic pyroxene andesite (N.C. 25) which apparently belongs to the mid-Tertiary series of extrusions briefly referred to earlier in the Synopsis and described in more detail hereafter in Section 5 of the Lower Beds. (See also Section D for petrographic description.)

The Older Volcanic (Whangakea) rocks appear to have very great thickness and lack fragmental eruptive material interbedded with the flows. These facts and their generally non-porphyritic (or aphyric) nature suggest that the lavas are the product of fissure eruptions in which the magma rose rapidly from considerable depths. Some at least of the flows were extruded under submarine conditions, as is indicated by the existence of pillow-lavas and thin beds of marine sediment associated with them, but the somewhat rare occurrence of such flows is suggestive that this was an exceptional condition.

Age of Older Volcanic (Whangakea) Series.

The age of the rocks described above is uncertain. McKay (1894) referring to rocks which are evidently those occurring with the pillow-lavas at Pandora, states: "From these rocks and from a calcareous red slate, I collected fragments of a fibrous shell apparently *Inoceramus*, and from a mass of grey and reddish limestone on the beach, numerous small shells of which the most abundant appears to be a species af *Halobia*." On this evidence, and on the supposed lithological resemblance between the older rocks of this area and Triassic and Jurassic sediments of the South Island, McKay placed the rocks here grouped in the Whangakea Series in a series ranging from "Older Secondary" to Palaeozoic in age. Hector (1894) refers to the fossils as "obscure fossils among which are fragments of fibrous shell and a small convex bivalve," and is disinclined to accept McKay's belief that the Pandora rocks are Triassic in age. Bell and Clarke (1910) bring forward no new evidence, and are content to quote McKay and Hector.

Stratigraphic evidence as to the age of the series discussed is meagre, and merely goes to show that there is strong unconformity between it and overlying mid-Tertiary strata, whilst its relations to the Upper Cretaceous Rahia series has not yet been observed.

Fresh, but somewhat indefinite, evidence of palaeontological nature has been unearthed. during the present expedition, in marly sediment bedded with the Pandora pillow-lavas. In thin section this proves to be a fine-grained calcareous rock compacted and streaked out by pressure and containing numerous tests of foraminifera (See Fig. 3). It appears to be a type of rock hitherto unknown from Hokonui (Trias — ? Neocomian) rocks of the North Island. Mr. W. J. Parr, of Melbourne, very kindly examined the somewhat crushed foraminifera and obtained the valued opinion of Mr. F. Chapman thereon. He writes that the foraminifera are certainly not Tertiary and may even be as old as Carboniferous. The provisional identifications include ***Bigenerina, Marginalina, Valvulina, Endothyra,*** and possibly ***Haplophragmium***. In addition, there are numerous spherical tests of a genus belonging to the Globigerinidae which closely resembles ***Orbulina.***

It will be seen that both palaeontological and stratigraphical data fail to furnish very precise information as to the age of the rocks discussed, so that the writers have depended very largely on diastrophic evidence in suggesting that these Older Volcanic or Whangakea rocks are flows erupted contemporaneously with the accumulation elsewhere of normal sediments of the mid-Mesozoic Hokonui

System, and are, in fact, the equivalents of the extensive sheets of basalt described by Bell and Clarke (1909) as interbedded with sediments of this system (Waipapa Series) in the Whangaroa district. This important diastrophic evidence is found in the presence at North Cape of gabbro which has invaded the Whangakea rocks and has primary foliation very strongly developed. It is considered most probable that the injection of this intrusion and its foliation are both the result of the Early Cretaceous orogeny which caused the emergence and folding of the Hokonui sediments from one end to the other of the New Zealand area, and initiated the period of vigorous erosion which preceded later Cretaceous sedimentation. If this be so, the Whangakea rocks must be at least as old as those of the Hokonui System.

There is admittedly a possibility that the series is of Cretaceo-Eocene age, for igneous rocks similar in character to the Whangakea lavas invade Upper Cretaceous sediments (Onerahi Series) in the watershed of Upper Mangakahia Stream and elsewhere in North Auckland, but against this view there are two main arguments. First, there is little evidence that the intensity of pressure involved in the post-Onerahi uplift and folding which preceded general mid-Tertiary sedimentation in North Auckland,* attained sufficient magnitude to develop foliation in the North Cape gabbros, whilst secondly, the foraminiferal fauna of the marl at Pandora is entirely different from that so far discovered in the foraminiferal "hydraulic limestone" of the Upper Cretaceous Onerahi series.†

2. UPPER CRETACEOUS SERIES (RAHIA SERIES OF BELL AND CLARKE).

The rocks included by Bell and Clarke (1910) in their Rahia Series occur at the south end of Rahia or Twilight Bay, in Taupiri Bay four miles north of this, and at Parenga, on what used to be Yates's station, but is now Mr. Chapman's property. McKay (1894) also placed certain "Cretaceo-Tertiary" greensands and siliceous mudstones from Dyson's old station on the north side of Parengarenga Harbour in the same series as the rocks of Yates's station. Though Bell and Clarke omitted the rocks near Dyson's from their Rahia Series, McKay's classification now proves to be correct, and Bell and Clarke's mapping erroneous in this respect. The rocks at Twilight (Rahia) Bay, which are included in this series, contain extensive associated pillow-lavas in addition to marine sediments. Those at Parenga consist of steeply inclined calcareous shales and mudstones alternating with moderately thick beds of concretionary greensands in which there are occasional thin bands of small pebbles. The concretions are often coated by a layer of cone-in-cone limestone and contain occasional fragments of a corrugated fibrous shell which is almost certainly *Inoceramus,* as well as rare casts of a small gasteropod.

*Benson (1923, p. 54) suggests that the northern portion of New Zealand came within the influence of intense orogenic movements which affected New Caledonia in the early Tertiary.

†Recent advice from Mr. W. J. Parr suggests that this statement may need to be modified.

The rocks mapped by McKay as "Cretaceo-Tertiary" north of Dyson's prove to be highly siliceous mudstones, with green sandstones, which are all considerably shattered and dip at high angles in irregular directions. Good outcrops are plentiful along the divides adjacent to the track from Dyson's to Waikuku Flat. This series of beds extends through to the coast near the south margin of the headland in which Maukin Nook is situated, for a boulder of green sandstone was picked up in the bed of a small stream at this place, in which there was a large fragment of the shell of an *Inoceramus*. This discovery obviously justifies McKay's mapping of the area as "Cretaceo-Tertiary."

Owing to unfavourable tides, the Taupiri Bay outcrops were not examined at beach level. The rocks exposed in the accessible higher portions of the sea-cliff at this locality, and those further north, apparently all belong to the Older Volcanic Series, so that it would appear that the Cretaceous or Rahia beds reported here by Bell and Clarke have very limited extent.

Amongst the most interesting of the beds assigned to the Rahia Series are those at Twilight (Rahia) Bay first recorded by Bell and Clarke (1910). Near the south end of the bay greenish and greyish sandstones dipping due north at 40° outcrop from beneath the sands of an adjoining dune-area. These are followed downward by a flow of pillow-lava about 70 ft. in depth, which has ovoid pillows from 1 ft. to 3 ft. in diameter. Each pillow exhibits small-scale radial prismatic jointing and a somewhat glassy chilled crust. (See Fig. 5). Beneath the lava there are what appear to be finely bedded clay-shales which are almost concealed by beach sands.

At the extreme southern limit of the beach in this bay, pillow-lavas are again developed in the sea-cliffs and shore-platforms; they dip steeply north at an angle of about 50°, the dip being clearly shewn by overfolding of individual pillows (see Fig. 2). Masses of secondary calcareous material and calcite occupy the interstices between the pillows, whilst this latter mineral is also abundant as the filling of joint crevices and vesicles. Above the flow, and apparently in part invaded by it, there are well-laminated indurated greyish mudstones which are exposed on the shore below high-water mark. Beneath the same flow there is a shattered breccia-like mass consisting of vesicular fragments of lava similar to that of the pillows, intermixed with a green matrix of doubtful nature but probably sedimentary. This breccia is interpreted as a scoria formed at the base of the uppermost flow of pillow-lava in this area. Passing further west, the breccia or "scoria" is succeeded in downward sequence by a stratum of green sandstone about 10 ft. in thickness which dips steeply north-east, and then by what appears to be a small mass of "baked" shale. Near this a dyke of dolerite 20 ft. in width is exposed on the shore-platform and is succeeded westward by highly amygdaloidal basalt lacking the pillow form. In the course of a few yards this last basalt passes into typical pillow-lavas which continue south along the rugged shore-line of Scott Point. Near the south end of Scott Point, a non-porphyritic open-grained basaltic rock was discovered a little east of the pillow-lavas in the valley of a small stream cutting steeply down to the shore from the elevated plateau

developed along the coast at this locality. It was at first believed to belong to the Older Volcanic Series of rocks, but its petrographic characters are not inconsistent with its description as a phase of the series of flows which nearby have the pillow form.

3. MIDDLE AND LATER TERTIARY BEDS (COAL POINT SERIES OF BELL AND CLARKE).

The area east of a line drawn from the western end of Spirits Bay Beach to Te Hapua, Parengarenga Harbour, exhibits locally thick, extensive sedimentary beds of Middle or Later Tertiary Age. Hector (1872), McKay (1894) and Bell and Clarke (1910) have mapped and described Tertiary rocks from this area, but their work is far from complete. Bell and Clarke grouped the beds in their Tertiary Coal Point Series along wtih rocks on the north side of Parengarenga Harbour which actually belong to the Upper Cretaceous (Rahia) Series.

Although there is no definite evidence of interformational unconformities subdividing the beds of the series, these latter constitute three more or less separate groups or sub-series: an upper group consisting of fossiliferous mudstones, sandstones, grits and minor conglomerates; a middle sub-series of andesitic conglomerates; a lower group which includes sandstones, tuffs, mudstones and a prominent basal conglomerate. These will be considered in ascending order.

(a). The Lower Beds of Coal Point Series.

The lower beds of the Tertiary Series are developed in five localities:—the eastern end of Spirits Bay in the vicinity of Hooper's Point; along the coast east of Huka Creek; on the coast at the east margin of Waikuku Flat; at Parengarenga North Head.

1. *The Hooper Point Section.*

At the east end of Spirits Bay andesitic conglomerates of the middle group are strongly developed on the north wall of the valley of Kapo Wairua stream, and in an islet near its mouth. After an interval, these are succeeded northward by a lower conglomerate which unconformably overlies flows of the Older Volcanic Series (Trias-Jura), and is composed of pebbles and fragments derived from this latter series. It is about 20 ft. thick, and, as already noted by McKay, its lower portion is crowded with the broken remnants of a large cirripede which is probably the same species—*Hexalasma aucklandicum*—as is found in the basal conglomerate of the Waitemata Series on certain islands of Hauraki Gulf near Auckland. Overlying the basal conglomerate there are beds of fine sandstone and mudstone, which are exposed on the steep hill-slopes above the sea-cliffs at this spot. These sediments then pass beneath the andesitic conglomerates of the middle sub-series and, with the basal conglomerate, constitute the lower group of Tertiary beds at this locality.

The section is repeated in the bluff just east of Hooper Point. The cirripede conglomerate, 25 ft. in thickness, is again seen to overlie the Older Volcanic (Whangakea) lavas, and is in turn succeeded by a thickness of from 100 ft. to 200 ft. of fine sandstones and mudstones, which contain concretions of pyrite and dip at 25° south.

Several faults traverse the area, and one has dropped the Tertiary beds described against the mass of Whangakea rocks which forms the extremity of Hooper Point just west of this section.

McKay's (1894) observations at this locality were faulty and led him to place the cirripede conglomerate as the lowest part of his "Manukau Breccias," which are here called the andesitic conglomerates. Bell and Clarke (1910) follow McKay in this error.

2. *The Huka Creek Section.*

Three-quarters of a mile west of the mouth of Waitangi Stream, Tom Bowling Bay, sediments of the lower sub-series of Tertiary strata outcrop at the coast from beneath the andesitic conglomerates of the middle sub-series, and continue to be exposed westward along the coast for a distance of about a mile. At the east end of the section the beds consist of alternate bands of sandstone and mudstone, followed by two beds, 6 ft. and 30 ft. in depth respectively, of fine volcanic grit in which are broken fragments of molluscan shells, and which are separated one from the other by a few feet of mudstone. In downward sequence these in turn are followed by further mudstones and sandstones with shell fragments, which dip east or north-east at an angle of about 20°. For the next 50 yds. the section is obscured, but later, at the mouth of a small creek, there is a very good exposure of fine-bedded mudstones which dip in the same general direction as the preceding beds, but at a lesser angle. A quarter of a mile east of Huka Creek thin tuffaceous beds are interbedded with the mudstones, which then pass down into about 80 ft. of fine-grained volcanic tuffs which dip at about 15° to the north-east and become decidedly coarser at their base. These tuffs rest on a breccia-like mass of crushed slickensided and weathered material, the fragments of which consist largely of the andesitic or basaltic rocks typical of the underlying Older Volcanic Series, but which also include masses, 18 ins. to 2 ft. in diameter, of diorite and of a glassy flow-breccia similar to that locally characterising the Older Volcanic rocks of Cape Reinga and Pandora. This basal material is regarded as the equivalent of the basal conglomerate of other Tertiary sections. Immediately west of the mouth of Huka Creek, the tuff and basal breccia are intersected by a fault with unknown throw which trends north and south and dips at 70° to the east. On the shore-platform the tuffs dislocated by it grade into a rock of "baked" aspect which contains small argillaceous fragments set in a fine argillaceous matrix, and which is invaded by a large dyke of diorite which forms the headland west of Huka Creek. Beyond the dyke, flows of the Older Volcanic Series again appear and continue for some miles westward to Hooper Point.

The extent of the Tertiary beds is evidently limited, for the valleys of the headwater tributaries of Huka Creek were found to be carved in Older Volcanic rocks which outcrop almost continuously in the beds of the streams.

Elsewhere than at this locality, the thickness of the beds of the Lower Sub-Series does not exceed 400 ft.; here their disposition indicates that it cannot be less than 1500 ft., unless (as is indeed highly probable, since one such fault is known to delimit the western margin

of the Tertiary beds of the Huka Creek area) there has been repetition of the strata by strike-faults.

3. *The Tawakewake Creek Section, Tom Bowling Bay.*

Tertiary rocks are again exposed at the mouth of Tawakewake Creek at the eastern end of Tom Bowling Bay, and for half a mile north-east along the coast. About 30 ft. of finely laminated sandy indurated mudstones project from beneath dune-sands on the western bank of the creek, and dip south-west at 35°. A sill of diorite, which has caused recognizable induration of the sediments, is in contact with them on their eastern margin, and continues for several hundred yards as a high coastal bluff to where its eastern, lower junction with the Tertiary sediments is clearly visible. These latter consist of about 40 ft. or 50 ft. of finely laminated sandy mudstones which dip south at 25°; some are highly indurated, remarkably fissile and varve-like. At the base of the section about 60 ft. of basal conglomerate unconformably overlies greatly shattered and disordered flows of the basement Volcanic Series. The conglomerate consists for the most part of angular fragments about 3 ins. in diameter derived from the subjacent Trias-Jura Volcanic Series, though fragments of much larger size are abundant. The cement is a highly calcareous material which is crowded with spines of echinoids and remains of bryozoans, while a few joints of a large *Isis* and several fragments of *Hexalasma* were also discovered.

McKay (1894) and Bell and Clarke (1910) do not appear to have visited this locality, for they make no mention of Tertiary rocks either here or at Huka Creek.

4. *The Wharekau Bay Section of Tertiary Beds.*

There is a further outcrop of the lower beds of the Tertiary Series in the sea-cliffs at the north end of Wharekau Bay, which is on the east coast about 2 miles south-east of the section that has just been described. This locality was visited by McKay and Bell and Clarke, but appears to have been rather cursorily examined.

At the north end of the beach the cliffs shew a considerable development of brown volcanic grits which dip gently south. McKay (1894) describes a band of "coralline and foraminiferal limestone" overlying these tuffaceous beds, but, as the tide was high, this could not be examined by the writers of this paper. A short distance further north, white sandstones outcrop high up in the cliffs and dip south above the grits, whilst a few hundred yards still further north there is a disturbed fault-zone in which the tuffaceous beds, the white sandstones and highly fissile sandy indurated shales similar to those of Tom Bowling Bay are all involved. A large mass of diorite about 400 yds. in width here invades the Tertiary rocks, and is exposed in a series of rocky bluffs along the coast. The brown arenaceous character of the weathered rock, and the regularity of its major joints, cause so remarkable a field resemblance to massive sandstone that it was mistaken for such by McKay. The outcrop of the Tertiary sequence is continued beyond the northern edge of the diorite in the sea-cliff about a mile and a half west of North Cape. The basal bed is a heavy breccia, 70 ft. or 80 ft. in depth, which is composed of

material derived from the Older Volcanic rocks which it unconformably overlies. It is overlaid by a finely-bedded, white sandstone of unknown though not great thickness, which dips at 20° to the south-south-west, whilst it is displaced by an oblique fault along which a dyke of dolerite is injected. Unfortunately, McKay failed to realise the nature and significance of the basal breccia, which he considered to be the lower part of his "Manukau Breccias."

5. *The Section at Parengarenga North Head.*

It is finally necessary to include in the lower sub-series of the Tertiary succession, carbonaceous green sandstones, mudstones and grits, with irregular lenses of impure lignite, which underlie the andesitic conglomerates of the middle Sub-series, and outcrop along a limited stretch of the shore-line east of Dyson's old station on the north side of the entrance to Parengarenga Harbour, though the beds were left unvisited by the present writers owing to lack of time. Hector (1872) gives a very complete description of the beds of this locality, in which he states that the general dip is about south-west and the total thickness of the beds exposed over 300 ft. On the evidence of plant fossils McKay (1894) correlates these rocks with the lignites and plant-bearing beds of Cooper's Beach, Mongonui, and of St. Paul's, Whangaroa.

Correlation of Lower Beds of Tertiary Series.

Summarizing the evidence disclosed by the sections, the following general upward sequence is recognizable in the Tertiary strata:—

(a) *Lower Beds.*
1. Coarse basal conglomerate. Marine. Depth generally considerable (up to 70 ft.), but only a few feet at Huka Creek.
2. Sandstones and mudstones which are largely marine in origin and of shallow water character. Partly terrestrial or lacustrine, for lignites are present at Parengarenga North Head. Depth at least 100 ft. to 200 ft., but may be as much as 1500 ft. in the Huka Creek section. Thick tuffs (100 ft. or more) are interbedded at Huka Creek, and at the north end of Wharekau Beach, at more than one horizon. The sandstones are invaded by a thick mass of diorite at the north end of Wharekau Beach and at Tawakewake Stream, at the east end of Tom Bowling Bay.

(b) *Andesitic Conglomerates,* about 1,000 ft. in maximum thickness, constituting the "Middle Beds."

(c) *Upper Beds.*—Thick sandstones at east end of Spirits Bay, at Wharekau and east of Flat Point, Parengarenga Harbour.

Owing to their misinterpretation of the lithological nature of the basal conglomerates, McKay and Bell and Clarke correlate the Lower Beds with the Andesitic Conglomerates ("Manukau Breccias") of Auckland district, and with similar fragmental beds at Whangaroa which Bell and Clarke (1909) have named the Wairakau Series. The presence of *Hexalasma* and other Tertiary fossils in the conglomerate suggests, however, that the Lower Beds should be correlated with the

Waitemata Series of Auckland, which lies immediately below the Manukau Breccias.

The contact of the Tertiary beds with the Upper Cretaceous sediments of the Rahia Series has not yet been observed, so that the exact relations of the two series is obscure. Nevertheless, the fact that the former strata rest directly upon the Older Volcanic Series in the vicinity of North Cape, though, on the northern shores of Parengarenga Harbour, at no great distance from North Cape, a great thickness of Rahia beds is developed, is better explained by supposing that near North Cape these latter were eroded from the basement of Older Volcanic rocks prior to Tertiary sedimentation, than by postulating overlap. The steeply folded and intensely shattered nature of the rocks of the Rahia Series, which contrasts with that of the Tertiary strata of the area, also suggests that the former were subjected to an early Tertiary orogeny which later beds were spared. This probability is strengthened by the evidence in favour of unconformity between probable Upper Cretaceous (Onerahi Series) and Tertiary (Waitemata Series) beds in the Whangarei and Auckland districts which has recently been brought forward by Ferrar (1921, 1925) and Bartrum (1924).

(b). *The Andesitic Conglomerates or the Middle Sub-Series of Tertiary Strata.*

The middle beds of the Tertiary Series are coarse andesitic conglomerates which have a maximum thickness of over 600 ft. and, in some places, of probably not less than 1000 ft. These conglomerates occupy the greater part of the area over which the Tertiary beds of the area now described are exposed, and outcrop along a continuous belt from the east end of Spirits Bay, through Munro's station at the north end of Parengarenga Harbour, to the east coast, where they outcrop discontinuously from the North Head of this latter harbour north to Wharekau Bluff. McKay (1894) and Bell and Clarke (1910) also map these rocks as extending in a strip from a short distance inland of the western end of Spirits Bay Beach, through to Waitiki Stream near Te Paki, whilst Bell and Clarke (*loc. cit.*, p. 619) record good exposures of them on the track from Parenga to Te Paki. Earlier maps appear to be incorrect in extending the conglomerate beyond the north bank of Waitiki Stream, for the writers traced the Older Volcanic (Whangakea) rocks for several miles east from Te Paki along the route to Te Hapua.

As will be shown in the section on petrography, the conglomerates consist essentially of well-rounded pebbles of andesite a few inches in diameter, which have been laid down in thick roughly-bedded strata. Their best outcrops are furnished by the occurrences at the east end of Spirits Bay, at the coast west of Waitangi Stream and in the headlands of the east coast such as those at Wharekau, at Maukin Nook, at Coal Point and at Parengarenga North Head.

At Spirits Bay the beds form a prominent cuesta which trends N.W.-S.E. and dips at 20° south-west to Kapo Wairua Creek, and are somewhat coarser in their material than elsewhere. West of Waitangi Stream the conglomerate is in well-bedded strata which dip at 20° to the east. The material there includes a fairly large propor-

tion of diorite in addition to the usual andesitic pebbles, and a number of irregularly shaped bombs with glassy chilled crusts.

On the south side of the headland at Wharekau the conglomerate is covered conformably at high levels by sandstones, and, towards the south, is followed at beach level by a series of sediments which dip south-west at 25° and closely abut against a mass of the conglomerates which is disturbed by faults causing rapid variations of direction of strike and dip. The actual contact of the two sets of beds is not visible, but it seems probable that the sediments belong to the Upper Sub-Series of Tertiary strata.

The direction and steepness of dip vary somewhat rapidly in the conglomerate at Wharekau and southward towards Coal Point, but, west from this latter locality, the dip is prevailingly towards the south-west, generally at angles of 15° or 20°. The synclinal structure recorded by Bell and Clarke (1910) could not be recognized. The beds of the headland in which Maukin Nook is situated have generally a gentle dip to the east, though Bell and Clarke (1910) record from here (= Coal Point of Bell and Clarke's map) a band of interbedded lignite 6 chains long and 1 ft thick which dips south at 35° The present writers did not see this bed for they did not visit the shores of the Nook itself, but they observed numerous carbonized and silicified tree-trunks, one not less than 20 ft in length and 1 ft. in diameter, and noted the abundance of shale and mudstone relative to andesite in the conglomerate, and the much smaller size of the constituent pebbles as compared with those of other outcrops.

At a small headland immediately south of Dyson's at the North Head of Parengarenga Harbour, the conglomerates outcrop in juxtaposition to débris of Upper Cretaceous (Rahia) beds. Their substantial conformity both with the sediments of the Upper Sub-Series of Tertiary beds and with those of the Lower Group below them is undoubted, and conditions of occurrence at Parenga and near Dyson's, taken in conjunction with evidence in favour of unconformity of the Upper Cretaceous to the Tertiary strata elsewhere in Auckland Province, suggest that the conglomerates have overlapped upon resistant erosion-residuals of Cretaceous rock.

On the east shore of a small inlet about a mile and a half east of Flat Point, Parengarenga Harbour, the andesitic conglomerates emerge from beneath a thick south-west dipping series of sandstones with which they appear to be conformable. These latter are mapped by McKay (1894) as *below* the conglomerates, but, in the absence of reliable palaeontological evidence, they are here placed on stratigraphic grounds in the overlying Upper Sub-Series of beds. As, however, the writers could not find time to visit the coastal section eastward towards Dyson's, and other perhaps vital areas immediately north of Te Hapua, they wish freely to admit the possibility that the sequence they have just described may have been inverted by thrust faulting.

(c). *The Upper Beds of the Tertiary Sequence.*

The Upper Beds of the Tertiary Coal Point Series include sandstones, mudstones. grits and minor conglomerates, which are developed extensively inland from Spirits Bay Beach and along the

northern shores of Parengarenga Harbour. Similar beds have minor development in sea-cliffs immediately south of Wharekau Bluff on the east coast. The maximum thickness of these Upper Beds may be as great as 1,000 ft.

Inland from Spirits Bay Beach the area underlain by these sediments consists of low hills which contrast strikingly with the much steeper and higher hills carved in the more resistant flows of the Older Volcanic Series to the west and in the andesitic conglomerates to the east, and, like these latter, often reproduce the cuesta type of divide. The strata of this area consist of soft sandstones, alternating with thinner beds of mudstone; they dip approximately south-west at low angles and are practically devoid of fossils. McKay describes them as conformably overlying the andesitic conglomerates, but Bell and Clarke map them as " Older Débris " of Pleistocene age. Their inclined disposition, conforming with that of the andesitic conglomerates, and their lithological difference from the Pleistocene accumulations of the area descibed in this paper, indicate, however, that Bell and Clarke's alteration of McKay's mapping is not justified.

Good exposures of sandstones, grits and mudstones with occasional thin lenses of greywacke-conglomerate, are displayed in the cliffs along the northern shore of Parengarenga Harbour for distances of about a mile north and two miles east of Flat Point, while conglomerates containing, amongst other material, flinty boulders apparently derived from subjacent Upper Cretaceous beds, appear to be interbedded with the finer sediments on the crests of the divides about a mile inland. The beds are fossiliferous, but no collecting was possible in the limited time available. Their dip varies considerably in magnitude, but preserves a fairly constant south to south-west direction. As already stated on p. 116 the writers place these beds *above* the andesitic conglomerates and not *below* them as was done by McKay (1894).

On the south side of Wharekau Bluff sandstones, with thin intercalated beds of mudstone, which lie conformably above the andesitic conglomerates constituting the bluff, are well displayed at high levels. A few chains south of these high-level outcrops there is a fault, and, beyond this, about 150 ft. of sandstones appear at beach level and dip south-west at 25°. Interbedded with them there is a tuffaceous band which contains a few large bryozoa, numerous fragments of crushed molluscan shells, broken echinodermal remains and occasional foraminifera. It appears probable that these are down-faulted representatives of the sandstones overlying the volcanic conglomerates.

4. PLEISTOCENE AND RECENT DEPOSITS.

Under the heading of Pleistocene and Recent deposits are included all those rocks which have accumulated since the first great uplift of the Kaikoura orogeny, which closed the cycle of Tertiary marine sedimentation in North Auckland approximately in early Pliocene times.

Possibly the oldest beds of this group are those described from the southern end of Twilight (Rahia) Bay by Bell and Clarke (1910) as members of their " Older Débris."

In this locality a horizontal basal bed about 2 ft. thick, composed of small well-rounded pebbles, rests unconformably upon older rocks (Rahia Series) and passes up into about 50 ft. of horizontally-bedded white and yellow sandstones, which, in turn, give place upwards to consolidated dune-sands.

Similarly, two small outliers of white sandstone, which lie above the andesitic conglomerates on the plateau-like divide immediately west of the mouth of Waitangi Creek, shew horizontal stratification and appear to be subaqueous in origin. Such gravels and sands are probably fluviatile deposits of local extent, which belong to the same series of beds as the dune-sands above them.

Drifting dune-sands of Recent age and their consolidated Pleistocene equivalents occur extensively along many of the coastal areas, particularly south of Cape Reinga and in the vicinity of Parengarenga Heads, and have a remarkable development in the giant tombolo south of the area described in this paper. Recent dunes characterise the coastal portions of areas where filling and progradation have followed the widespread and considerable depression, which, as already noted in the Physiography Section, affected the North Cape-Cape Maria van Diemen terrain in common with the rest of North Auckland in Sub-Recent times.

In some localities, notably about three-quarters of a mile east of Cape Maria van Diemen, the consolidated dune-sands contain thousands of shells of terrestrial gasteropods (see Fig. 7), amongst which are the following species:—*Placostylus hongii ambagiosus* Sut., *Rhytida duplicata* Sut., *Realia turriculata* Pf., *Paryphanta busbyi* (Gray), *Serpho kivi* (Gray) and others *

Similarly, innumerable ancient Maori middens and ovens are exposed in the dune areas of the coasts, and, whilst human bones and chips of obsidian are often very abundantly associated with these, polished implements or ornaments are surprisingly scarce.

As these Recent and Pleistocene sands have been described in detail by previous writers, nothing further need be added in the present description, unless to make mention of the remarkable bad-land topography carved at the north end of Twilight Bay from ancient dune material (see Fig. 4), and to remark on the fact that, a little east of the sand-dune area of this locality, the deep clays of less elevated portions of the topography are highly suggestive of loess.

In addition to the types of deposit already described there are alluvial gravels and silts which mantle terraces and small flood-plains in the lower reaches of many of the streams and belong to this group of beds, whilst there are also estuarine sands with Recent molluscs, which have been described by McKay (1894) as building extensive flats, such as that at Flat Point, about 10 ft. or 15 ft. above high-water level around the borders of Parengarenga Harbour.

*The writers are indebted to Mr. A. W. B. Powell for identification of some of these species.

INTRUSIVE ROCKS AND GENERAL PETROGRAPHY.

This section of the present paper is reserved for description of the igneous rocks, which may conveniently be grouped as follows:—

A. Intrusive Rocks.
 Rocks intrusive into members of the stratigraphic series already described.
B. The Older Volcanic (Whangakea) Series and Later Pillow-Lavas.
C. The Mid-Tertiary (Coal Point Series) Conglomerates.
D. Igneous Rocks of Uncertain Horizon.

A. INTRUSIVE ROCKS.

The intrusive rocks of the district may be considered to fall broadly into two main groups which are based upon both field and petrographic characters. One of these lends itself to further subdivision.

1. Peridotitic and Gabbroid Rocks of the Kerr Point-North Cape Mass. Probably Early Cretaceous in age.
2. Minor Intrusions.
 (a) Dykes of diorite and dolerite of pre-Miocene age.
 (b) Dioritic intrusions in the Coal Point sediments. Probably Miocene in age.

1. *Peridotitic and Gabbroid Rocks of the Kerr Point-North Cape Mass.*

General Description.

A most interesting series of ultrabasic and gabbroid rocks was discovered by Bell and Clarke (1910) at the coast near North Cape and Kerr Point. Whilst the present authors cannot claim to have made a thorough examination of the area, they consider, nevertheless, that Bell and Clarke overestimate the importance of noritic or gabbroid rocks in relation to the peridotitic. The coast at North Cape, and thence north-west for half a mile and south-west for over a mile, consists, it is true, wholly of gabbroid rocks, but at Kerr Point ultrabasic rocks were followed continuously from both the west and the east margins of their occurrence for distances aggregating well over half a mile, and preponderated in quantity over the gabbroid. The dominant rocks proved to be peridotites and pyroxenites which are generally in relatively unaltered state, though sometimes considerably serpentinized. These have been intersected by numerous small discontinuous lensoid bodies or larger dykes of gabbroid rocks, which shew considerable variety both in mineralogical constitution and texture, and are especially prominent on the western margin of Kerr Point. At this last locality they include an extremely coarse norite containing hypersthene, hornblende and diallage, in which the crystals are sometimes over 4 ins. in largest dimension. It is almost impossible to separate the various ultrabasic rocks one from another in the field, for partial serpentinization of olivine completely masks the character of many types. Microscope sections demonstrate, however, that they differ rather markedly in the proportions of the olivine and pyroxenes present, and range from dunite-serpentine to lherzolite and wehrlite. One section of serpentine (N.C. 19) shews that

the rock from which it was cut may have been derived from harzburgite of which the original enstatite is now represented by "bastite," but not one of the 31 slices cut from various portions of the gabbroid and ultrabasic intrusions shews any identifiable enstatite, though numbers possess hypersthene which contains relatively so little iron that its pleochroism is scarcely distinguishable. The optical character of the mineral was tested time and time again, and proved always to be negative, whilst the curvature of the hyperbolic brushes in interference figures indicated an optic axial angle less than that of either enstatite or bronzite. It thus appears probable that the mineral recorded by Bell and Clarke (1910, p. 623) as enstatite should be called hypersthene.

As already remarked, it is difficult to estimate exactly what part harzburgite-serpentine or dunite-serpentine plays in the make-up of the main intrusion, for insufficiently numerous sections of the general serpentine, of which most other types appear to be subsidiary phases, were made to do more than establish the presence of both facies.

Wehrlite (N.C. 18, 18a) possessing different degrees of coarseness of grain is very abundant on the west edge of Kerr Point, whilst on its eastern border, a little north-west of North Cape, there is a considerable mass of lherzolite, as already described by Bell and Clarke (*loc. cit.*). Pyroxenites similarly are occasionally prominent, as is exemplified by a websterite (N.C. 52) on the western portion of the Kerr Point promontory, and by a lherzolitic rock (N.C. 14) immediately west of the North Cape lherzolite that has just been mentioned.

Detailed Description of Ultrabasic Intrusive Rocks.

In the rock described as wehrlite (N.C. 18, 18a), diallage, and serpentinized olivine associated with the usual strings of magnetite, are sub-equal in amount, the large rather rounded crystals of the former being enwrapped by the latter (see Fig. 8). In section N.C. 18a the lamellar twinning of the diallage is made obvious by what appears to be incipient alteration to some unidentified product. In the lherzolite (N.C. 1, 38) the grain-size is large, for crystals ½ in. or more in length are not uncommon. The proportions of olivine to pyroxene vary, but the former mineral is at least equal in amount to the latter. The olivine is partially serpentinized and has given rise to dense strings and masses of secondary magnetite. In one section (N.C. 38) the pyroxene is mainly hypersthene which exhibits fine-scale lamellar twinning and poicilitically encloses chondri of olivine, but there is also a little colourless monoclinic pyroxene which appears to be augite. In the other section (N.C. 1) the augite is perhaps more abundant than the hypersthene, though in much smaller crystals. A little interstitial altered basic plagioclase is present, whilst small amounts of bastite, talc and uralite are associated with the pyroxene. The lherzolitic rock (N.C. 14) recorded from near the typical lherzolite just described, contains a greatly reduced quantity of olivine (25 per cent.). There is no feldspar and the pyroxene is mainly augite, though polysynthetically-twinned hypersthene is represented by a few crystals. Some of the pyroxene is permeated by minute vermiform markings which seem to be elongated fluid inclusions, though their

appearance strongly resembles that obtained with micrographic intergrowth. Brownish-green hornblende occurs in ragged crystals which are chiefly concentrated along a narrow shatter-zone; with it there is a quantity of secondary bladed actinolite, whilst chlorite and talc are found elsewhere as derivative of the pyroxene.

The websterite (N.C. 52) recorded above is essentially a diallage rock, though hypersthene is also an important constituent; incipient alteration has again caused the lamellar twinning of the diallage to be especially obvious.

In addition to the pyroxenites described, there are occasional small dykes of an altered diallage rock (N.C. 11) in which a small quantity of greenish hornblende, tinged here and there by brown, is the only constituent besides the diallage.

This latter mineral is often altered to an almost opaque whitish product in which the high birefringence of the original mineral is still recognisable.

Gabbroid Rocks of the Minor Intrusions Associated with the Ultrabasic Complex.

Gabbroid dykes invade the peridotites and allied rocks described in the last section, especially on the west margin of the mass. In hand-specimen the rocks of these dykes are generally normal coarse-grained types. Their varieties include granophyric quartz gabbro; anorthosite or anorthositic gabbro; olivine norite or gabbro; gabbros and norites with occasional hornblende in addition to both monoclinic and orthorhombic pyroxenes; and finally gabbros in which the usual pale-green augite is largely converted to uralite.

The granophyric quartz gabbro and the olivine gabbros or norites were not located *in situ*, but were identified from sections cut from large beach boulders at the west margin of Kerr Point. The quartz gabbro (N.C. 53) has a most unusual structure. Uralite is an abundant constituent; it is associated with cores of almost colourless greenish augite and a small amount of probable hypersthene and is in slightly less quantity than plagioclase (basic labradorite). The latter mineral is in two generations, for there are crowded nests of lath-like crystals about 0.4 mm. in length around which large crystals of plagioclase have crystallized (see Fig. 11). Meanwhile, the uralitized pyroxene ophitically enwraps the feldspar and occasional large masses of iron ore. Finally, there is a moderate quantity of interstitial micrographically intergrown material, which consists of quartz and an albite-twinned feldspar possessing an index of refraction greater than that of Canada balsam.

Generally the feldspars present very clean-cut idiomorphic borders to the micropegmatitic material, but in a few instances the margins of the larger crystals are somewhat ragged. Dr. W. N. Benson has suggested in explanation of the unusual relations between the two generations of feldspar, that the larger crystals began crystallization at an earlier date than the smaller, but later continued the process contemporaneously with the latter, and thus finally were moulded upon them.*

*Personal communication.

The more typical gabbros vary rapidly in facies as a result of differences in the proportions of the constituent minerals. More leucocratic phases are represented by anorthositic rocks which occur as narrow dyke-like portions of larger gabbroid masses with the usual abundant ferromagnesian minerals. One such rock when sectioned (N.C. 39) proved to be composed of about 80 per cent. of plagioclase (? basic labradorite), with a little over 15 per cent. of colourless monoclinic pyroxene (? diopside) and a relatively large amount of rather strongly pleochroic sphene. This last mineral occurs as small wedge-shaped crystals, which are collected in bar-like aggregates in close association with the pyroxene, and possibly represent original ilmenite. The feldspar is somewhat shattered, so that exact determination of its variety proved impracticable. Another unusual leucocratic rock forms conspicuous veinlets, a few inches wide, in the lherzolite north-west of North Cape. It is a coarse-grained rock with dark ferromagnesian crystals as much as 1 in. in length, and quite a number of small amber-coloured grains of sphene visible in hand-specimen. Whitish material constitutes about 75 per cent. of the rock and proves in section (N.C. 76) to be plagioclase which is now largely converted to scales of a moderately highly refractive and strongly birefringent mineral. This has positive optical character and negative elongation, so that it is probably prehnite. With the prehnite there are minute ramifying veinlets of actinolite, whilst the large dark crystals of ferromagnesian mineral are brown hornblende or a pale-green variety fringed with brown. The sphene recognised macroscopically is not plentiful in section.

Amongst other gabbros, mention may be made of an irregular lens-like intrusion of hornblende gabbro (N.C. 42) which penetrates the serpentine near its extreme westerly margin at Kerr Point. Its feldspar (basic labradorite) varies from point to point in its proportions relative to hornblende, but appears generally to be in excess of this latter. It is associated with derived rosette-like groups of prehnite and minute spherulitic growths of chlorite. There is a large amount of pale-green to bluish-green primary hornblende, and abundant fibrous secondary amphibole, wedged in between crystals of plagioclase, whilst in parts of the section there are relatively large masses of sphene and magnetite. The structure is coarsely holocrystalline and frequently ophitic. Hypersthene and pale-green augite or diallage are the most plentiful ferromagnesian constituents, and, though all have been more or less converted to uralite, augite is the first to suffer such alteration. The hypersthene generally exhibits the usual multiple twinning, and frequently is minutely intergrown with monoclinic pyroxene disposed along the composition planes of the twin. Hornblende generally accompanies the pyroxene, usually forming intergrowths with this latter. It is doubtful whether or not it is primary; it may be magmatically derived from pyroxene as so often appears to be the case with the amphibole of gabbroid rocks. Usually it is greenish-brown in colour, but may be pale-green.

Hypersthene and monoclinic pyroxenes (both augite and diallage) are present in nearly all the varieties of gabbroid rocks, and in such nearly equal proportions that the latter must be classed as noritic gabbros. There is no hypersthene, however, in a uralite-augite

gabbro (N.C. 50) which forms a 20 ft. dyke on the extreme west border of the peridotites. Olivine norite-gabbro was identified only from large beach boulders. About 8 per cent. to 10 per cent. of olivine is present in the rocks sectioned (N.C. 49, 58); it is in moderately unaltered crystals which accompany the other ferromagnesian minerals usual in these rocks.

The Noritic Gabbro of North Cape.

An extensive mass of gabbroid rock forms the coast for about half a mile north-west and over a mile south-west from North Cape. The rock is typically a fine-grained basic type, but is subject to variations in texture, and, near North Cape itself, is strongly gneissic in structure (see Fig. 9). The foliation is believed to be due to piezo-crystallization; it is very regular in orientation and trends approximately N.W.-S.E. with a dip of 20° to the south-west. Locally it is on a very fine scale, but more generally it is coarse and regular, exhibiting laminae about ¼ in. in depth which are alternately rich in feldspar and ferromagnesian minerals. West of North Cape this gneissic rock is associated with lherzolite, but the mutual relations were not determined.

It is difficult to conceive how the variations of structure and certain alternations of texture and mineralogical differences shewn by different parts of the main gabbroid intrusion can be due to divergences in the rates of cooling of different portions of a single injected magmatic body, and, although no supporting evidence was obtained in the field, it appears more probable that the intrusion was not a single event, but partook of the nature of a multiple injection of bodies of almost identical magma, probably at closely spaced intervals of time. On this hypothesis, the gneissic portion of the gabbro is capable of two interpretations. In the first place it may be considered the earliest phase of the invasion of magma. If this be so, the unilateral pressure responsible for its foliation must largely have found relief before later injections occurred, for the only suggestion of oriented stress furnished by other rocks of the mass lies in granular pyroxene and ragged, bladed uralite illustrated by two of the sections prepared from representative rocks.

As an alternative, it is conceivable that the gneissic gabbro was the last phase of the intrusion, and that the earlier associated gabbros had been intruded in advance of an epoch of severe pressure which accompanied the injection of the gneissic body. Following this view, the foliation of this latter, lacking in the earlier gabbros, was possible only because of high temperature (the temperature of solidification) acting in conjunction with pressure. The first of these interpretations, namely, that the foliated portion of the gabbroid intrusion represents the earliest phase of the injection, appears to the writers to be the more probable.

The gabbroid rocks prove microscopically to be more or less ophitic noritic gabbros in which the femic minerals are generally in excess of the feldspar (either basic labradorite or bytownite). The ferromagnesian minerals are generally augite, hypersthene and uralite, which is extensively developed from both pyroxenes, though more especially from the augite. In one or two rocks (N.C. 8, 10) conver-

sion to uralite has almost been completed (see Figs. 12, 13). In most instances augite has been present originally in greater quantity than hypersthene. In one slide (N.C. 10) a little probable quartz is present, though it does not lend itself to ready identification. In this same rock, there is also a little minutely micrographic material and a small quantity of an interstitial mineral, in fibrous radial sheaf-like aggregates, which appears to be a feldspar. In another rock (N.C. 9), brownish-green hornblende is plentifully associated with pyroxene as if intergrown with it, and appears to be derived from the latter mineral. The pyroxene is in small granular crystals about 0.2 mm. in diameter, whilst the plagioclase has especially ragged outlines as a result, it is believed, of unilateral pressure. (See Fig. 10).

A number of narrow holocrystalline dykes of lighter colour than the general rock penetrate the gabbro south-west of North Cape. Of those sectioned, one (N.C. 40) is very similar to the diopside-sphene-rich rock described by Bell and Clarke (1910, p. 623) as forming dykes in the lherzolite near North Cape, but differs in possessing a greater amount of feldspar. The rock here described is an even-grained holocrystalline type with about 50 per cent. of colourless pyroxene (? diopside), between 1 per cent. and 2 per cent. of sphene and the remainder basic labradorite. The rock of another such dyke (N.C. 4) was found to be a quartz-augite diorite. The feldspar (acid labradorite) is in rather lath-shaped crystals and dominates over almost colourless partially uralitized augite. There are groups of sphene and iron-ore, though these minerals are not unusually abundant, whilst quartz constitutes about 10 per cent. to 15 per cent. of the rock. Still another type (N.C. 24) is dominantly feldspathic, with only about 15 per cent. of pyroxene (? diopside) and with about 2 per cent. of sphene. The feldspar is greatly altered and weathered, and is replaced here and there by large clear masses of a zeolite which resembles natrolite.

An analysis of a typical moderately coarse-grained noritic gabbro (N.C. 48) from near the southernmost margin of the gabbroid mass is given in Column 1, Table 1. The rock is somewhat ophitic, with about 40 per cent. of modal plagioclase, and is relatively free from decomposition or alteration. Augite is slightly in excess of hypersthene, and has been the later of the two to crystallize, for it is often moulded upon the hypersthene. The analysis calls for no special comment apart from its high percentage of lime, which is co-ordinated with a high proportion of normative anorthite.

Age of the North Cape-Kerr Point Intrusives.

West of Kerr Point, and also on the east coast a short distance south of Whiriwhiri Stream, the peridotites and gabbros appear to invade the flows of the Older Volcanic Series, which are intensely shattered and crushed near the contact, and frequently are impregnated with pyrite, which is also found in some of the intrusive rocks themselves. They thus definitely post-date the Older Volcanic Series, and, as already indicated in a previous section, though the date of intrusion may therefore possibly be Eocene (p. 109), the gneissic nature of some of the rocks in question strongly supports the probability that they were injected in Early Cretaceous times, and broadly

speaking, accompanied the great orogenic movement which closed the Hokonui period of sedimentation in New Zealand.

2. MINOR INTRUSIONS.

In addition to a closely related series of intrusions forming part and parcel of the Kerr Point ultrabasic and gabbroid mass, there are a number of injections which fall fairly completely within two groups so far as date of intrusion is concerned.

The earlier group has invaded rocks of the Older Volcanic (Whangakea) Series of probable Trias-Jura age at a date prior, it is believed, to the conclusion of the orogeny which terminated the prolonged Trias-Jura sedimentation, for the rocks of several of the intrusions indicate by bent lamellae of plagioclase, and other signs, that they have been subjected to considerable pressure during or since their consolidation.

If the Older Volcanic Series is correctly assigned to the Hokonui System, it would then appear most probable that the early Cretaceous orogeny not only affected the lavas of this series but also the rocks of intrusions which were themselves an accompaniment of the early phases of the orogeny.

The second group of intrusions referred to intrudes into the sediments of the Coal Point Series (? Miocene).

(a). *Pre-Miocene (? Early Cretaceous) Intrusive Rocks.*

Most of the dykes included in this group are placed there because, as has just been stated they intrude into the older volcanic rocks and shew evidence of having been subjected to intense pressure since their consolidation. Though the intrusions are quite small, their rocks have plutonic facies, thus indicating that considerable depths of the original cover have been removed since the injection of the dykes. It is by no means improbable that the period of intrusion of the majority was the same as that of the Kerr Point ultrabasic and gabbroid mass.

The examples recorded could doubtless have been increased considerably if thorough examination of the northern coast had been practicable.

They are:—

1. A wide dyke of micrographic pyroxene-quartz diorite (N.C. 61) outcropping at the shore about 1 mile east of Cape Maria van Diemen.
2. A narrow dyke of pyroxene diorite (N.C. 2) discovered in the sea-cliff near the mouth of the stream at Pandora, Spirits Bay.
3. An intrusion, probably of limited size, represented by large blocks on the east wall of the valley at Pandora about 300 yards south from the shore-line. Its rock is an augite diorite containing brown hornblende (N.C. 41).
4. A doleritic dyke, 21 ft. wide, trending N.65° W., associated with pillow-lavas at the southern end of Twilight (Rahia) Bay. There is no evidence of pressure having affected the rock of this intrusion, but its petrographic similarity to the pillow-lavas suggests that it is the hypabyssal equivalent

of these latter, which the writers have included in the Upper Cretaceous Rahia Series.

Macroscopically this rock closely resembles a greensand upon casual inspection, but the rocks of the other dykes in this group are typical fine-grained dioritic types.

Examined microscopically the pyroxene-quartz diorite (N.C. 61) recorded from 1 mile east of Cape Maria van Diemen proves to be a moderately even-grained holocrystalline rock containing approximately 60 per cent. of plagioclase (acid labradorite) in lath-like crystals which seldom exceed 1 mm. in length, and which are built around about 25 per cent. or more of sub-idiomorphic slightly titaniferous pyroxene and about 10 per cent. of ilmenite in large crystals. Here and there are masses of minutely micrographically or spherulitically intergrown material enclosing large crystals of plagioclase or other earlier mineral. The spherulites appear to be almost wholly feldspathic; the micrographic intergrowths are on so fine a scale that exact identification of the constituent minerals is not possible, yet a small amount of quartz was detected elsewhere in the section and it is probable that both quartz and feldspar (? orthoclase) are present in the intergrowths. There is no evidence that the material is myrmekite. It appears rather to be a product of end-stage crystallization as described by Colony* for similar intergrowths in noritic rocks from Sudbury, Ontario, and elsewhere.

The pyroxene diorite from Pandora (N.C. 2) is a weathered fairly coarse-grained rock with abundant very pale green augite in granular aggregations which suggest shattering by pressure Larger, less plentiful crystals of hypersthene accompany the augite Secondary amphibole and chlorite abound in some parts of the slide and may be in stellar and sheaf-like forms. The pyroxene-hornblende diorite from the Pandora valley is similarly an altered and weathered type with prominent kaolin and chlorite. The femic minerals are subidiomorphic deep-brown hornblende with a less amount of pink titaniferous augite and 4 per cent. or 5 per cent. of ilmenite. There are numerous small sharp prisms of apatite and a very little radially fibrous mineral which appears to be a feldspar. Plagioclase constitutes about 60 per cent. of the rock by volume but is so weathered that its variety was not determined with certainty; it is apparently basic andesine.

The last of the rocks described in this group—the dolerite from Twilight Bay (N.C. 33)—is a coarse-grained ophitic rock which has been greatly altered and weathered. Pinkish, faintly pleochroic augite (about 25 per cent.) and ilmenite (about 5 per cent.) in long irregular rods are the only primary femic minerals, unless rare chloritic pseudomorphs preserving cracks and form suggestive of olivine actually represent that mineral. The plagioclase sometimes encloses close-spaced needle-like prisms of brown hornblende or of pale-green augite. Needles of apatite are ubiquitous. Weathering again militates against exact determination of the variety of the plagioclase. It is, however, at least as basic as acid labradorite. The

*R. J. Colony, The Final Consolidation Phenomena in the Crystallization of Igneous Rocks, *Journ. of Geol.*, vol. 31, 1923, pp. 169-178.

secondary minerals include chlorite, a little opal, chalcedony in radially built masses and a poorly refractive and poorly birefringent mineral in radial or divergent fibres which is associated with the chalcedony. It generally is very deeply clouded, or even rendered almost opaque as a result of some form of decomposition, and is referred with considerable doubt to some or other zeolite (? stilbite).

The classification of this rock as a dolerite is perhaps open to doubt in view of the uncertainty of the variety of the plagioclase. Its strongly ophitic structure, however, points to this being its correct position.

(b). *Intrusions in the Coal Point Sediments (? Miocene).*

Three important intrusions were located in sediments of the Coal Point Series (? Miocene) not far from Kerr Point and North Cape. One of the largest is a sill of quartz-augite diorite (N.C. 5), 300 ft. or 400 ft. in depth, which intrudes into fine-grained sandstones near the base of the Coal Point Series as developed at the east margin of Tom Bowling Bay. Its lower surface is distinctly chilled and accords perfectly with the stratification of the laminated sandy mudstone beneath it. The mudstone exhibits no sign of metamorphism other than slight marginal induration at the western margin of the sill near the mouth of Tawakewake Creek.

In hand-specimen the diorite is a compact fairly finely crystalline rock which weathers deeply to a sandstone-like mass which can only be determined as igneous in relatively fresh examples. It contains about 45 per cent. of feldspar (acid labradorite), 15 per cent. of quartz and a very small quantity of micrographically intergrown quartz and orthoclase; the balance of the rock is mainly pale green augite with a moderate quantity of uralite, some greenish-brown hornblende, and magnetite in normal quantity.

A second member of this group of intrusions outcrops on the east coast a little north of Waikuku Flat. It is a mass of micrographic quartz diorite (N.C. 23) similar to the preceding one, but its relations to the intruded strata are not discernible and its thickness is greater than that of the sill just described. In its weathered condition at its outcrop it so closely resembles a sandstone as to have been described as such by earlier workers. In section the rock is dominantly feldspathic, the feldspar (acid labradorite) being in stout lath-shaped crystals which are accompanied by about 15 per cent. of quartz, and a lesser quantity of chlorite which is associated with occasional ragged remnants of brownish green hornblende and a little magnetite. There are, in addition, a fairly large proportion (10 per cent.) of micrographically intergrown quartz and feldspar which enwrap earlier minerals (see Fig. 17), and a few needles of apatite.

The third intrusion of this period intersects heavy basal conglomerates of the Coal Point Series outcropping on the coast 1½ miles west of North Cape. It proved to consist of a most interesting coarse-grained doleritic rock (N.C. 30) which includes alkaline varieties amongst its feldspars. These latter minerals constitute 50 per cent. of the rock, and are generally in lath-shaped crystals about 1 mm. in length; basic labradorite is the dominant variety, but there are also occasional crystals of albite, others of probable orthoclase and several

fairly large anhedral ones of an unidentified alkali feldspar closely crowded with vermiform growths of chlorite. It has a refractive index considerably lower than that of Canada balsam, and shews faint, highly irregular sub-microscopic twinning reminiscent of that of anorthoclase. An additional section was made from the only duplicate available, but failed to shew any trace of the mineral in question, and it is therefore believed to be present as xenocrysts. There is a possibility that this feldspar is albite, for lath-shaped crystals of this mineral were detected by their low refractive index and positive optical character, but the irregular outline of the (?) anorthoclase suggests that its origin, in any case, differs from that of the more tabular albite. The analysis of this rock (No. 2 of Table 1, p. 131) shews its relative basicity. The content of alkalis, though not high, is above the average and is clearly due to the presence of modal alkali feldspar.

Immediately west of Huka Creek, Tom Bowling Bay, there is a massive intrusion which outcrops at the shore-line for several hundred yards, and which, though intersecting the Older Volcanic Series, has been injected along the course of a fault which dislocates the basal tuffs of the Coal Point Series in this locality. This mass thus belongs to the same period of intrusion as the others of this section and is, moreover, a micrographic quartz-augite diorite (N.C. 59) closely similar to other intrusive rocks of this period. The micrographic material is in comparatively small amount, whilst the augite is accompanied by a very little brownish hornblende.

In view of the fact that all four of the intrusions just described definitely post-date the Lower Beds of the Coal Point Series, it may be affirmed with safety that they were injected in later Miocene times, during the period of igneous activity which gave rise to semi-basic lavas from which the andesitic conglomerates of the Coal Point Series were derived.

B. Older Volcanic (Whangakea) Series and the Pillow-lavas.

Normal Whangakea Lavas.

One of the ubiquitous characters of the lavas classed here as the Older Volcanic Series is their poverty in phenocrysts. Rarely indeed is it possible to detect these latter in hand-specimens. It is unusual to find a succession of flows spread over a comparatively wide area which shew such uniformity in this respect, and this fact suggests that the uprise of the magma to the surface from considerable depths was a rapid process.

The lavas of this series have suffered extensive shattering and locally have been comminuted by shearing to such an extent that their true nature is completely masked, and only made decipherable by the discovery of cores of uncrushed igneous rock in the general shale-like material. Veinlets composed mainly of calcite, but with subsidiary zeolite, occupy the interstices between the fragments resulting from this shattering.

McKay (1894) was excusably misled by their aphyric character, into regarding this series of rocks as consisting of greywackes and shales. Bell and Clarke (1910), whilst shewing obvious doubt as to

FIG. 1.—View looking west to Cape Reinga, whence according to Maori tradition the spirits of the dead depart for the next world. Older andesites. Note the characteristic wave-cut platforms (tide nearly full).

FIG. 2.—Pillow-lavas at south end of Twilight Bay. The flow dips steeply to the left.

FIG. 3.—Photomicrograph of foraminiferal marl associated with pillow lavas of the Older Volcanic Series at Pandora (Whangakea), Spirits Bay; magnification 45 diameters.

Fig 4 —Bad land topography developed in consolidated dune sands Twilight Bay

Fig 5 —Pillow lavas unconformably overlain by Pleistocene bedded gravels and sands, near the south end of Twilight Bay

Fig 6 —Homoclinal ridge of andesitic conglomerate overlying Tertiary sandstones and mudstones, east end of Spirits Bay

Fig 7 —Fossil shells of *Placostylus hongii ambagiosus* and other terrestrial gasteropods in consolidated dune sands, south-east of Cape Maria van D

Fig. 8.

Fig. 9.

Fig. 8.—Wehrlite (N.C. 18) from Kerr Point intrusion, shewing slightly altered lamellar diallage and partially serpentinized olivine.

Fig. 9.—Gneissic norite-gabbro (N.C. 55) from near North Cape, with bands alternately rich in pyroxene and plagioclase.

Fig. 10.

Fig. 11.

Fig. 10.—Fine-grained phase of norite-gabbro (N.C. 9) from southwest of North Cape, shewing plagioclase and granular pyroxene. Nicols crossed.

Fig. 11.—Granophyric quartz gabbro (N.C. 53) from beach boulder on the western margin of Kerr Point. Nests of small laths of plagioclase are enwrapped by large crystals of the same mineral, the whole being enveloped by pyroxene. Nicols crossed.

Magnification of figures, 38 diams.

Fig. 12. Fig. 13.

Fig. 12.—Noritic gabbro (N.C. 8) from south-west of North Cape, shewing plagioclase, and secondary amphibole replacing pyroxene. Nicols crossed.

Fig. 13.—Finer phase of noritic gabbro (N.C. 10) from south-west of North Cape. The pyroxene is almost completely converted to uralite.

Fig. 14. Fig. 15.

Fig. 14.—Subophitic andesitic basalt (N.C. 12) from Older Volcanic Series in bed of Huka Creek. Laths of plagioclase enwrapped by partially chloritized augite. Nicols csossed.

Fig. 15.—Picritic basalt (N.C. 17); pillow-lava from 3 miles east of Hooper Point. Phenocrysts of plagioclase are enclosed in a (?) hyalopilitic groundmass of chloritized augite and laths of plagioclase.

Magnification of figures, 38 diams.

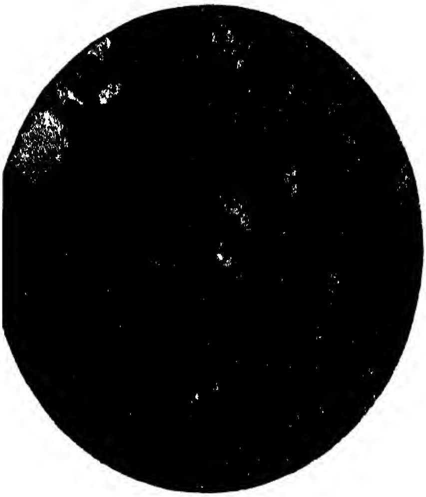


FIG. 16

FIG 17

FIG. 16—Pillow lava (N C 29) from south end of Twilight Bay. A pseudomorph after olivine enclosed in a plexus of laths of plagioclase.

FIG 17—Quartz diorite (N C 23) from east of Waikuku Flat, east coast, shewing plagioclase and quartz enwrapped by a micrographic intergrowth of these two minerals Nicols crossed

FIG. 18.

FIG 19.

FIG 18.—Andesite (N.C 26b) from conglomerates of Coal Point Series, west side of mouth of Waitangi Stream, Tom Bowling Bay Phenocrysts of plagioclase, ilmenite and augite in a groundmass of plagioclase enclosing radially grouped needles of hornblende.

FIG. 19—Andesite (N.C 43a) from conglomerates of Coal Point Series, west of Waitangi Stream, shewing a vesicle filled with concretionary opal and zeolite (central part).

Magnification of figures, 38 diams

their true nature, followed McKay's lead, but brought to light some interesting details of intrusives injecting the series, and also noted the "orbicular" structure of some of the flows comprising it, which are, in actual fact, perfect examples of pillow-lavas.

These latter are best seen in two outcrops near Pandora at Spirits Bay, but they are also exposed on the shores of a cove three miles east of Hooper's Point and doubtless in other places which the writers were unable to visit. At Scott's Point there is a most extensive outcrop of highly characteristic pillow-lava, but there are grounds for believing that it belongs to a later period of extrusion than other flows of this type.

The exact microscopic determination of the members of the Older Volcanic Series is difficult on account of chloritization and other alteration. All are semi-basic or basic in character, and range from quartz andesites to fairly basic basalts which are free from modal olivine in all but the pillow-lavas. The rocks generally consist microscopically of a plexus of rather small laths of plagioclase quite devoid of fluxional arrangement, along with variable proportions of more or less chloritized pale-green or pale-brown augite and some iron-ore. In a few instances, notably in a mass (N.C. 12) comparatively little affected by shattering which outcrops in the wide-spread valley of Huka Creek, Tom Bowling Bay, ophitic and sub-ophitic structure appears. (See Fig. 14).

The variety of plagioclase is andesine-labradorite in the more acidic, and is as basic as Ab_{40} An_{60} in the more basic members of the series. The laths are very often bent in response to severe pressure which doubtless has also caused the shattering already referred to. The proportion of iron-ore varies from about 1 per cent. to about 7 per cent.; both magnetite and ilmenite are represented.

Quartz-augite andesite was collected from the shore at the west margin of the Kerr Point ultrabasic and gabbroid mass; it is a much-altered type with very abundant chlorite, some epidote and comparatively little identifiable quartz. A quartz-uralite andesite with about 10 per cent. of quartz was sectioned, but unfortunately its locality was omitted in the field-labelling.

A rock kindly forwarded with others by Mr. H. MacQuarrie from the shore a few yards south of the pillow-lava at Pandora, has small lenses of dark-reddish-brown material in a greenish altered lava which proved in section (N.C. 80) to be a fine-grained non-porphyritic olivine-free basalt. It is traversed by veinlets of zeolites and by occasional narrow crush-zones.

Microscopically examined, the reddish lenses (N.C. 79) are found to consist of an indecipherable shale-like material closely traversed by veinlets of calcite associated with a zeolite. If the rock were actually shale entangled in the associated lava, it expectably should shew some sign of mineral reorganisation. It does not do so, however, and it is perhaps possible to regard it as comminuted and completely altered portions of the associated basalt. There is support for this latter suggestion in somewhat similar alteration traceable adjacent to the pillow-lavas a few yards away. Sections of these latter have such dense oxidation products that the original structure of the rocks is considerably obscured.

In a small rill entering the sea at the north end of the first sandy beach south of Cape Reinga, a blackish glass was found which had entangled large blocks of the normal lava, and had so created a flow-breccia. Similar material was noted at the base of the Tertiary sequence at Huka Creek, Tom Bowling Bay, and amongst specimens forwarded by Mr. MacQuarrie from the shore ¼ mile west of Pandora, Spirits Bay. In thin section the glass is a deep-brown almost opaque variety. It encloses scattered, rather small crystals of augite and plagioclase.

Bell and Clarke (1910, p. 622) describe an altered augite andesite from Darky Hill (Tirikawa), west of Spirits Bay; it has moderately large phenocrysts of augite and plagioclase and a groundmass which apparently has been hyalopilitic. A similar rock (N.C. 83) was collected by Mr. McQuarrie from the shore ¼ mile west of Pandora. It has idiomorphic phenocrysts of both plagioclase and augite, the former in elongated altered crystals about 0.8 mm. in length and the latter a colourless variety quite unaffected by alteration or decomposition. The groundmass is in considerable excess of the phenocrysts, and its structure greatly obscured by weathering. The augite present in this matrix is in minute prisms which are often grouped side by side to form fringes to the larger laths of plagioclase.

The remainder of those of the Older Volcanic rocks which have been examined microscopically either fall on the border-line between andesites and basalts as defined by Washington,* or are more definitely basalts, for the percentage proportions of modal femic minerals range from about 35 to as much as 65. Two examples of more basic basalts are yielded by a rock (N.C. 80) out-cropping a few yards south of the pillow-lava at Pandora, and by a hyalopilitic type from a small cove 3 miles east of Hooper's Point. This last basalt (N.C. 6) contains numerous small phenocrysts of augite along with a few of plagioclase, and, following Washington (*loc. cit.*), is to be classed as a picrite-basalt. (See Fig. 15).

An analysis of the rock from Taputaputa, a little over 2 miles east of Cape Reinga, is appended in Column 3 of Table 1, whilst its norm is in the corresponding column of Table 2.

In section this type is an olivine-free, non-porphyritic andesitic basalt, consisting essentially of a plexus of unoriented laths of plagioclase (Ab_{45} An_{55}) enclosing about 40 per cent. of almost colourless augite sub-ophitically related to the plagioclase. (Compare Fig. 14). The analysis demonstrates that the rock unquestionably is a basalt, though with a leaning towards the andesites as defined by Washington (*loc. cit.*). The variety of plagioclase determined in section is more basic than that shewn by the norm, whilst the normative olivine in actual fact has separated out as pyroxene.

*H. S. Washington, Petrology of the Hawaiian Islands; I. Kohala and Mauna Kea, Hawaii. *Am. Journ. Sc.*, vol. 5, 1923, pp. 465-502.

ANALYSES OF IGNEOUS ROCKS.

TABLE 1.

ANALYSES.

	1.	2.	3.
SiO_2	48.12	49.82	49.76
Al_2O_3	14.07	17.61	15.72
Fe_2O_3	3.85	0.96	2.31
FeO	5.38	4.66	6.52
MgO	7.03	9.78	7.15
CaO	8.62	14.67	9.85
Na_2O	2.68	1.23	3.68
K_2O	1.44	0.10	0.34
H_2O+	3.29	0.56	2.55
H_2O-	3.51	0.19	0.56
CO_2	None	0.04	Trace
TiO_2	1.92	0.25	1.04
ZrO_2	—	None	None
P_2O_5	0.07	0.03	0.10
S	0.01	0.03	0.12
Cr_2O_3	None	0.03	0.03
V_2O_3	0.04	—	—
NiO	—	0.04	0.03
MnO	0.16	0.15	0.22
SrO	0.04	None	Trace
BaO	None	Trace	Trace
	100.23	100.15	99.98

Analyses by Mr. F. T. Seelye

TABLE 2.

NORMS.

	1.	2.	3.
Quartz	0.60	—	—
Orthoclase	8.34	0.56	1.67
Albite	23.06	10.48	31.44
Anorthite	21.96	42.26	25.30
Diopside	16.55	24.43	18.41
Hypersthene	13.58	17.72	5.02
Olivine	—	1.98	9.28
Magnetite	5.57	1.39	3.02
Ilmenite	3.65	0.46	1.98
Pyrite	—	—	0.23
Apatite	—	—	0.34

1. Dolerite N.C. 30) from dyke in basal Tertiary beds, 1½ mile west of North Cape.
2. Noritic gabbro (N.C. 48), southern margin of gabbroid mass, North Cape.
3. Basalt from Older Volcanic Series (N.C. 51), Taputaputa, east of Cape Reinga.

The Pillow-Lavas.

As has been noted elsewhere in this paper, it is believed that not all of the pillow-lavas of the Cape Maria van Diemen-North Cape area belong to the Older Volcanic Series, but they are so closely allied petrographically that it is convenient to describe all together. They resemble the rocks of this last-mentioned series in being severely shattered and altered. The individual pillows vary in diameter from 1 ft. to 3 ft., and, in their best development, shew a more or less distinct radiate, finely prismatic structure and a chilled crust which is clearly

illustrated in Fig. 5. Some are decidedly overturned and elongated in the direction of flow. (See Fig. 2).

The rock of the pillow-lava at the northern margin of Scott's Point is finely vesicular, and exhibits in hand-specimen a moderate number of red pseudomorphs of carbonate and haematite after olivine. A little below what appears to be the uppermost flow of the series exposed at the south end of Twilight (Rahia) Bay, and immediately west of a dyke of green dolerite, there is a massive aphyric amydaloidal rock of similar nature to the pillow-lava, but devoid of olivine, which is soon followed westwards by further pillow-lavas which form the sea-cliffs for about two miles at Scott Point, but which were not examined microscopically. The pillow-lava at the south-end of Twilight Bay and the associated amygdaloid are probably best classed as basic andesites and andesitic basalts, for they are intermediate between andesites and basalts. In the present writers' sections of the pillow-lava (N.C. 29), pseudomorphs after olivine are the only phenocrysts, though Bell and Clarke (1910, p. 622) have noted occasional labradorite in addition to the olivine in their slides. About 70 per cent. of the rock consists of laths of weathered plagioclase, which form an unoriented open-textured matrix (see Fig. 16) in which are a little very pale green augite and about 5 per cent. of rod-like ilmenite. The amygdaloidal olivine-free aphyric basalt has a less proportion (about 60 per cent.) of plagioclase. There is a large quantity of pink augite with densely crowded ilmenite and magnetite. The augite is generally in curious closely appressed minute sub-parallel prisms, though sometimes in divergent or radial groups. No exact determination of the variety of plagioclase proved possible. In most instances the extinction angles obtained with albite twin-lamellae were small. Albite was suspected, but, so far as the weathered condition of the mineral allowed determination, refractive index tests negatived any possibility of the occurrence of this mineral.

Bell and Clarke (1910, p. 622) compare the pillow-lavas at Pandora with those at Scott Point, but state that the crystals of olivine are free from alteration, more frequent, smaller and corroded, whilst there are no phenocrysts of plagioclase. The present writers' sections are so obscured by hematitic and other oxidation products as to render determination of olivine impracticable. A small mass of lavas having imperfect pillow form, which outcrop at a small cove 3 miles east of Hooper Point, consist of an olivine-free chloritized basalt possessing numerous phenocrysts of almost colourless augite accompanied by a few groups of small crystals of plagioclase. There is abundant pyroxene in the groundmass, with about 25 per cent. of plagioclase in diversely arranged relatively long laths, and a moderate amount of iron-ore which is mainly ilmenite.

Summing up the facts, it is evident that there is no petrographic reason for separating the pillow-lavas from other members of the Older Volcanic (Whangakea) Series. The Twilight Bay-Scott Point pillow-lavas have been grouped with the Cretaceous Rahia Series, and thus separated from other similar flows, only because of their association with sediments which are quite dissimilar from any of Trias-Jura age yet known from New Zealand, but closely resemble Cretaceous beds at Parenga.

C. THE PETROGRAPHY OF THE MID-TERTIARY (COAL POINT SERIES) CONGLOMERATES.

The conglomerates of the mid-Tertiary Coal Point Series preserve a dominantly igneous character throughout their wide extent of outcrop, and somewhat rarely contain any noteworthy proportion of pebbles of sedimentary rocks. Bell and Clarke (1910, p. 619) record sedimentary material in the conglomerate outcropping on the trail between Parenga and Te Paki, whilst the present writers found it in moderate abundance at Maukin's Nook on the east coast.

A very large number of microscope sections were cut from constituent fragments of the conglomerate west of Waitangi Stream and at the east end of Spirits Bay, but little important variation was discovered. Bell and Clarke describe the prevailing type as a hyalopilitic augite andesite with a large amount of glass, and remark on the lack of importance of hypersthene which is so ubiquitous in the pyroxene andesites of the similar conglomerates and breccias of the Waitakerei Ranges near Auckland. The present study shews, however, that hypersthene is no whit less abundant than in the southern rocks; there is, however, greater lithologic variety in the northern than in the Waitakerei conglomerates.

Boulders of dioritic, and more rarely, of gabbroid rocks, which have been derived from intrusions such as those described in an earlier section, though never very plentiful, can nearly always be found after brief search, whilst, as is to be expected, representatives of the earlier (? Trias-Jura) volcanics are also discoverable.

Hyalopilitic pyroxene andesites with both augite and hypersthene, usually with plagioclase as the most abundant phenocryst as well as the most important constituent of crystalline portions of the groundmass, are apparently the prevailing types. Phenocrysts and matrix are sub-equal in amount. The matrix shews all gradations from a variety with comparatively little glass (e.g. N.C. 34, o) to distinctly vitrophyric types in which the minerals of the second generation are represented only by tiny microlites. The rocks are remarkably free from signs of alteration, though rare chloritic pseudomorphs after possible olivine were noted in one or two of them. The phenocrysts are idiomorphic and seldom exceed 1 mm. in length. Those of plagioclase very often contain numerous minute glass or mineral inclusions, and generally vary in variety from andesine-labradorite to acid labradorite, though, in one more basic rock (N.C. 34, e), the feldspar is labradorite-bytownite. This particular rock is one of the few with pseudomorphs of chlorite after olivine, and further exhibits abnormal basicity in possessing proportionally more pyroxene as compared with feldspar than the andesites associated with it, for the two minerals are sub-equal in amount.

Other types of andesite identified include the following:—vitrophyric augite-hornblende andesite with quite a number of small phenocrysts of brown hornblende in addition to those of plagioclase and augite; fine-grained varieties with imperfectly crystallized matrix and few phenocrysts; hyalopilitic augite andesite with curious sheaf-like grouping of the plagioclase in the groundmass (N.C. 70, a); a special type of andesite (N.C. 26, b) with augite and some green

hornblende. About 75 per cent. of this last rock consists of large idiomorphic crystals of plagioclase (Ab_{40} An_{60}) as much as 1.5 mm. in length and numerous smaller ones (about 0.2 mm. in length) of the same mineral, with a greatly subordinate quantity of very pale greyish augite and a little ilmenite. The balance of the rock is a "matrix" consisting partly of clear colourless glass and partly of feldspar in large irregular crystals which enclose numerous minute needles of green hornblende, these latter very often being grouped in stellar fashion. (See Fig. 18).

The same envelopment of earlier prismatic hornblende by later plagioclase is exhibited by two other rocks sectioned, both of them highly feldspathic, though with a little augite. One is almost identical with the rock just described, but for the fact that the texture is even-grained. Large stumpy laths of labradorite are more or less ophitically enwrapped by a minor proportion of augite, whilst the last-crystallized feldspar, as before, is crowded with minute prisms of deep-green hornblende.

In addition to the hyalopilitic andesites described, there are closely allied perlitic vitrophyric rocks (N.C. 34, k, m, n, p) which bear very close similarity in section to certain rocks from the Whangarei-Bay of Islands area described by one of the present writers in a chapter of a recent Geological Survey bulletin (Ferrar, 1925). These proved on analysis to be andesitic dacites. About 60 per cent. of the bulk of these perlitic rocks is a glass colourless in section and containing numerous lath-shaped crystals (about 0.2 mm. in length) of plagioclase, and prisms of hypersthene and augite, the former in greater profusion than the augite, whilst there is also a variable though important quantity of deep-brown hornblende. The glass itself is crowded with trichitic microlites; in some slides these have so increased in size as to be mineralogically determinable, though in such cases the glass has lost its clarity and become more opaque.

The older andesitic rocks sectioned (N.C. 34, h; 43, a) resemble the rocks typical of the series (Whangakea Series) to which they belong, and are largely composed of laths of basic labradorite which make an open-textured unoriented mesh. There is about 4 per cent. or 5 per cent. of ilmenite in relatively large crystals whilst about 10 per cent. of pale-greyish-green partially chloritized augite is entangled in the mesh of plagioclase and, at times, ophitically enwraps this last mineral. In one of the two slides (N.C. 43, a) large prisms of secondary quartz have crystallized in drusy spaces in company with opal, a radially fibrous zeolite, chlorite and a little pyrite. Chlorite has lined the cavities and has then been followed by the opal which has crystallized as tiny radially built concretions. (See Fig. 19).

The gabbroid and dioritic rocks sectioned have their prototypes in the similar pre-Tertiary intrusive rocks which already have been described. The gabbros (N.C. 34, d; 34, e) are a uralite-augite variety and another containing uralite with both hypersthene and augite.

The diorites have plagioclase (labradorite) dominant over ferromagnesian minerals; they include an augite diorite with a little brownish-green hornblende and some micropegmatite (N.C. 72), and

quartz diorites containing uralite associated with plentiful cores of augite (N.C. 15, b), or else augite with a little greenish-brown hornblende (N.C. 15, c).

West of the mouth of Waitangi Stream, Tom Bowling's Bay, the Tertiary conglomerates contain numerous small fragments of black chilled igneous rock which in section prove to consist of a brown glass with a few small phenocrysts of augite and plagioclase. These represent the chilled crust of andesitic bombs.

D. IGNEOUS ROCKS OF UNCERTAIN HORIZON.

An andesitic rock (N.C. 25) which outcrops on the shore-platform about half a mile east of Pandora, Spirits Bay, proved on sectioning to be an unaltered hyalopilitic hypersthene-augite andesite identical with the similar rocks of the conglomerates of the Coal Point Series. It is adjoined by typical members of the Older Volcanic Series, but unfortunately its petrographic separation from these latter was only determined when microscopic slides had been prepared, so that its field relations were not carefully observed. It was believed to be a small intrusion, but the distinct parallelism of its numerous lath-shaped phenocrysts of plagiolcase and certain other characters suggest rather that it is an extrusion. If this rock actually represents a lava, the explanation of its occurrence presents many difficulties which are otherwise non-existent, so that, in the absence of more precise knowledge, it has provisionally been classed as a dyke rock in the section on stratigraphy.

A number of boulders of a white volcanic rock were discovered at the mouth of Pandora Creek, Spirits Bay. It consists of an irresolvable light-grey "earthy" matrix which encloses numerous small idiomorphic phenocrysts of plagioclase, and great numbers of much smaller lath-shaped crystals of the same mineral, along with scattered small euhedral crystals of deep-brown hornblende and a little magnetite. The plagioclase is very finely zoned and is relatively free from lamellar twinning. The rock is microscopically indistinguishable from many of the trachytic dacites which have been described by one of the writers (Bartrum, 1925) from the Whangarei Heads district. Its chemical nature could only be determined by analysis, but it was considered that the labour of analysis was scarcely justified whilst nothing was known of its field relationships.

Acidic dyke rocks were also located by the writers at Mt. Camel in the Hohoura district, 29 miles south-south-east from North Cape; several of them exhibit phenomena indicative of severe strain, so that their injection probably occurred before the commencement of the Early Cretaceous deformation which terminated Hokonui sedimentation. The Pandora rock, on the contrary, lacks any evidence of strain and is therefore probably an early Tertiary effusive approximately contemporaneous with similar acidic rocks in the Whangarei-Bay of Islands Subdivision (Ferrar, 1925).

THE STRUCTURE OF NORTH AUCKLAND PENINSULA.

In discussion of the structure of the Whangarei-Bay of Islands Subdivision, Ferrar (1925, p. 18) has recently summarized many of

the various opinions with regard to the structure of North Auckland Peninsula, but has found the distortion of the basement Hokonui (Waipapa Series) rocks of his area too great to permit of any safe generalization of fold-directions therein. He suggests, however, on the basis of the trend of certain greywacke ranges, that " . . . the Mesozoic earth movements were in the nature of folds along north-west to south-east axes, the folds bending over eastward toward a submerged area." However correct this conclusion may prove, it must be observed, nevertheless, that the trend of these ranges is probably largely governed by the N.W.-S.E. fracture-system accompanying later Tertiary emergence of the New Zealand area, and believed by Park (1921) to determine the framework of the peninsula.

As already remarked, these fractures can be clearly followed from an originating source in the Taupo region, where they meet the immense fractures of a N.E.-S.W. system (Henderson, 1924), through Auckland to Whangarei and the Bay of Islands (Ferrar, 1925, pp. 18-21), until they finally reach North Cape.

Benson (1924, p. 132) remarks how, in the New Zealand region, these fracture-systems generally cross the trend-lines obliquely, as had been noted earlier by Cotton (1916) for the southern part of North Island, and states the possibility of regarding the New Zealand-Kermadec ridge " . . more as a complex fault-horst than as a fold-anticline," though Brouwer, he states, believes " that a geanticline growing at depth is represented by a fractured ridge."

Bell and Clarke (1909, pp. 42-43) find the general trend of a major anticlinorium in the inland portion of the Whangaroa area to be E.N.E.-W.S.W., though nearer the coast the folds approximate a W.N.W.-E.S.E. direction. They are in agreement with Marshall (1908; 1911, p. 5), who found a dominant north or north-east trend in the Bay of Islands and in localities further north, that the arrangement of the basement rocks of Whangaroa Subdivision shews no relation to the alignment of North Auckland Peninsula. In the north of Great Barrier Island, however, the strike of rocks of the same system is approximately N.W-S.E. (Bartrum, 1921), though near Coromandel it is approximately meridional (Fraser Adams, 1907, p. 26.).

In view of the frequent disparity of direction between the axis of the peninsula and the fold-axes shewn by these observations, it is surprising to find that the foliation of the gneissic gabbro at North Cape, in common with the folding of the sediments at Great Barrier, accords in direction with the backbone of North Auckland. It is well known by those familiar with the Hokonui rocks, as developed in North Auckland, that stratification is seldom distinct, except in areas characterised by complex minor folding such as would tend to obscure the general trend of the strata. It is therefore probable that an erroneous conception of the direction of the major folds has been gained, as appears to be the opinon of Morgan (1922), and that, in the present state of our knowledge, it is unwise to accept Benson's (*loc. cit.*) generalization concerning the obliquity of intersection of fracture-lines with trend-lines in the New Zealand area, as applying unreservedly to North Auckland.

The evidence at Great Barrier Island and North Cape undoubtedly supports Suess's (1913) view that fold-axes open out to the north and north-west from the main structural axis of New Zealand, and pass through North Auckland as an integral part of his "Third Australian Arc." Following Brouwer's suggestion (*fide* Benson, *loc. cit.*) the N.W.-S.E. fractures of the late Tertiary orogeny (Kaikoura orogeny of Cotton) are perhaps the result of geanticlinal folding following the early Cretaceous axis along which the Hokonui rocks were up-arched. This is the "closing Tertiary" Australasian crustal undulation of Andrews (1923, p. 2) progressing "from the continental nucleus to the Central Pacific, the prominence of the forms and the relative youth of the activities being accentuated with progressive approach to the main ocean itself."

LIST OF LITERATURE.

ANDREWS, E. C., 1923. Geographical Distribution of Ore Deposits in Australasia, *Econ. Geol.*, vol. 18, pp. 2-25.

—— 1923 (a). Supplementary Note on the Geology of the Broken Hill District, *Mem. Geol. Surv. N.S.W.*, No. 8, Supplement.

BARTRUM, J. A., 1921 Notes on the Geology of Great Barrier Island, New Zealand, *Trans. N.Z. Inst.*, vol. 53, pp. 115-127.

—— 1924. Geology of the Riverhead-Kaukapakapa District, Waitemata County, Auckland, *Trans. N.Z. Inst.*, vol. 55, pp. 137-153.

—— 1925. The Igneous Rocks of North Auckland, New Zealand, Gedenboek Verbeek, *Verhand. v.h. Geol.-Mijnb. Gen. v. Ned. e. Kol.*, Geol. Ser., Deel 8, pp. 1-17.

—— 1926. "Abnormal" Shore Platforms, *Journ. of Geol.*, vol. 34, No. 8, pp. 793-806.

BARTRUM, J. A. and LAWS, C. R., 1924. *The Geology of the Papakura-Hunua District*, MS. in possession of Auckland University College.

BELL, J. M., 1909. Reconnaissance of North Cape Peninsula, *N.Z. Geol. Surv. 3rd. Ann. Rep.* (n. s.), pp. 5-6.

BELL, J. M., and CLARKE, E. de C., 1909. The Geology of the Whangaroa Subdivision, *N.Z. Geol. Surv. Bull.* No. 8 (n. s.).

—— 1910. A Geological Reconnaissance of Northernmost New Zealand, *Trans. N.Z. Inst.*, vol. 42, pp. 613-624.

BENSON, W. N., 1920. Tectonic Conditions Accompanying Intrusion of Basic and Ultrabasic Igneous Rocks, *Bull. Geol. Soc. Am.*, vol. 31, pp. 145-148.

—— 1923. Palaeozoic and Mesozoic Seas in Australasia, *Trans. N.Z. Inst.*, vol. 54, pp. 1-62.

—— 1924. The Structural Features of the Margin of Australasia, *Trans. N.Z. Inst.*, vol. 55, pp. 99-137.

—— 1926. The Tectonic Conditions Accompanying the Intrusion of Basic and Ultrabasic Igneous Rocks, *Mem. Nat. Acad. Sci.*, vol. 19 (First Memoir).

COTTON, C. A., 1916. The Structure and Later Geological History of New Zealand, *Geol. Mag.*, dec. 6, vol. 3, pp. 243-249, 314-320.

FERRAR, H. T., 1924. Rodney Subdivision, *N.Z. Geol. Surv. 18th Ann. Rep.* (n. s.), pp. 6-7.

FERRAR, H. T., and CROPP, W. H., 1921. Whangarei and Bay of Islands Subdivision, *N.Z. Geol. Surv. 15th Ann. Rep.* (n. s.), pp. 6-8.

FERRAR, H. T., and Others, 1925. The Geology of the Whangarei-Bay of Islands Subdivision, *N.Z. Geol. Surv. Bull.* No. 27, (n. s.).

FRASER, C., and ADAMS, J. H., 1907. The Geology of the Coromandel Subdivision, *N.Z. Geol. Surv. Bull.* No. 4 (n. s.).

Hector, J., 1872. Report on Coal Seams at Whangaroa and Mongonui, Auckland, *Rep. Geol. Expl.* 1871-72, pp. 153-158.

—— 1894. Parengarenga and North Cape, *Rep. Geol. Expl.* 1892-93, Prog. Rep., pp. 16-20.

Henderson, J., 1924. The Structure of the Taupo-Rotorua Region, *N.Z. Journ. Sci. and Tech.*, vol. 6, pp. 270-274.

—— 1924 (a). The Post-Tertiary History of New Zealand, *Trans. N.Z. Inst.*, vol. 55, pp. 580-599.

McKay, A., 1894. The Geology of Hokianga and Mongonui Counties, North Auckland, *Rep. Geol. Expl.* 1892-1893, pp. 70-90.

Marshall, P., 1908. Geology of Centre and North of North Island, *Trans. N.Z. Inst.*, vol. 40, pp. 79-98.

—— 1911. New Zealand and Adjacent Islands, *Handbuch der regionalen Geologie*, Bd. 7, Ab. 1.

—— 1912. *Geology of New Zealand*, Wellington.

Morgan, P. G., 1921. Geological Sketch Maps of New Zealand. (See also *N.Z. Journ. Sc. and Tech.*, vol. 5, 1922).

—— 1922. Notes on the Geology of New Zealand, *N.Z. Journ. Sc. and Tech.*, vol. 5, pp. 46-57.

Park. J., 1910. *Geology of New Zealand*, Wellington.

—— 1921. Geology and Mineral Resources of Western Southland, *N.Z. Geol. Surv. Bull.* No. 23, (n.s.).

Smith, S. P., 1881. On Some Indications of Changes in the Level of the Coast-line in the northern part of the North Island, *Trans. N.Z. Inst.*, vol. 13, pp. 398-410.

Suess, E., 1913. *La Face de la Terre* (French Translation), vol. 3, pp. 1049-1053.

Mollusca from Kaawa Creek Beds, West Coast, South of Waikato River.

By J. A. BARTRUM AND A. W. B. POWELL.

[*Read before the Auckland Institute, 4th October, 1927; received by Editor, 8th January, 1928; issued separately, May 24th, 1928.*]

PLATES 25-31.

IN 1919 one of the present authors described a new fossiliferous Tertiary horizon at Kaawa Creek (Bartrum, 1919, a),* publishing a list of mollusca based on determinations by the late Mr. A. Suter. At the same time he published descriptions of several new species determined as such for him by Mr. Suter (Bartrum, 1919, b). The original material was limited to that obtainable from two or three small blocks fallen from an inaccessible spot in the sea-cliffs about 50ft. above beach level. During recent years, however, a large slip has afforded a splendid opportunity for collecting, and Bartrum has been able to make further collections during short periods available when on field excursions with students. He is greatly indebted to several of these students for their assistance, especially as a new species described in this paper was collected by one of them—Mr. F. J. Turner—in 1924. He further wishes to thank Mr. Powell for kindly collaborating in this paper and bringing to its preparation his surprising knowledge of modern molluscs and the resources of his extensive collections.

Both authors owe much to Dr. J. Marwick, who has kindly lent types for comparison and has examined one or two new species of doubtful generic position, as well as furnishing critical notes upon the original collection.

REVISION OF LIST OF KAAWA MOLLUSCA.

The original list of mollusca from Kaawa Creek (Bartrum, 1919, a) has been revised by Dr. Marwick after examination of collections made by the New Zealand Geological Survey as well as of that of Bartrum, and the revised list was published by Henderson and Grange (1926). Recent collecting, however, has added new records, whilst many nomenclatural changes have been introduced during recent revision of various genera, so that a fresh list of the mollusca so far found in the Kaawa beds is appended. This could be greatly extended by systematic collecting, which has not yet been attempted

DESCRIPTION OF NEW SPECIES AND GENERAL REMARKS.

Unless stated to the contrary, the shells described or discussed have been collected by J. A. Bartrum and are in the Auckland University College Collection.

*See list of literature for reference in this and similar cases.

Emarginula striatula Q. and G.

The Kaawa shells are slightly narrower than the Recent species, which they otherwise resemble closely.

Montfortula kaawaensis (Bartrum).

Finlay (*Trans. N.Z. Inst.*, vol. 57, 1926, p. 344) refers *Tugali kaawaensis* Bartrum to the genus *Montfortula.*

Tugali opuraensis n. sp. (Fig. 20).

The shells listed as *Tugali bascauda* Hedley and *T. intermedia* (Reeve) by Bartrum (1919, a) prove to belong to the same species, which is described, on the basis of fresh material, as a new species allied to the Recent *T. elegans* Gray (= *T. intermedia*)—(see Finlay, *loc. cit.* pp. 344-5).

The sculpture is the same as that of the Recent species, the trifurcation of the central rib from the nucleus being especially well shewn in a small paratype (6.4 mm. x 3.9 mm. x 1.9 mm.). The apex is, however, nearer the anterior end, its distance from this latter being one-eleventh of the length of the shell in the holotype and one-sixth in the paratype, whilst in *T. elegans* Gray this ratio varies in different specimens examined from one-fourth to one-fifth approximately.

Dimensions of holotype: 11 mm. x 6 mm. x 2.4 mm.

Trochus bibaphus n. sp. (Figs. 21 and 22).

This species is represented by a solitary shell which was collected by Mr. F. J. Turner in 1924.

Its tall conical shape appears to indicate that it is the direct ancestor of *T. huttoni* (Cossmann) (see. Finlay, *loc. cit.*, p. 349) Though its spire angle is close to that of this latter shell, its suture is abutting and the peripheral margin of its base sharper.

General sculpture consists of low, flat, smooth cinguli alternating with fine threads on spire-whorls. Oblique growth-lines fairly prominent. On the base 13 cinguli without intervening threads. On the antepenultimate whorl 9 primary cinguli, whilst both *T. tiaratus* Q. and G. and *T. huttoni* (Cossman) have 5. Protoconch slightly worn. Colour (still preserved) pink, faintly checked by small elongated rectangular splashes of white carried at regular intervals on the cinguli.

Dimensions of holotype: Height, 9.2 mm.; width, 10.7 mm.

Spectamen cf. **egena** (Gould).

Finlay (*loc. cit.*, pp. 358-360)has discussed the genus *Monilea* Swainson, 1840, and, anticipating distinctive radular characters, has introduced a new generic name *Antisolarium* for the species *M. egena* (Gould), which Powell (*Rec. Cant. Mus.*, vol. 3, pt. 1, 1926, p. 45) has included in the genus *Spectamen.* This forecast of radular differences, however correct it may ultimately prove, scarcely justifies the rejection of *Spectamen.* If carried to a logical conclusion, such procedure would prohibit all provisional generic allocations based only on shell characters and would thus undesirably and unnecessarily multiply generic names.

The Kaawa shell represents a new species ancestral to *S. egena* (Gould), but is too poorly preserved to be worth specific description.

Elachorbis cingulatus (Bartrum).

This name replaces *Circulus cingulatus* (Bartrum) of the early list of Bartrum (1919, a). See Iredale, 1915, p. 444.

"Turbo" postulatus Bartrum (Figs. 6 and 7).

Bartrum (1919, b, p. 100) described under the above name a shell, identified by the late Mr. A. Suter as a *Turbo,* which was represented only by a basal fragment. Recent collecting has added over twenty specimens in varied states of preservation. The shell material is very thin and fragile, so that it proved impossible to collect any specimen with the apex at all well preserved.

As better material is now available, a neotype has been selected for description. The species does not appear to be strictly a *Turbo*, for it differs from most shells placed in that genus in the extreme thinness of the shell-material, in the imperfect glaze on the parietal wall, generally allowing continuation of the sculpture on the inner lip, and in the discontinuous peristome. The columella is very strongly developed.

The shell shews affinities with *Tonna,* but discordant features are the rather straight columella and the apparent absence of the basal siphonal notch, which may, however, be represented by slight sinuosity near the base. It is, further, much smaller than known New Zealand species of *Tonna.*

For these reasons it has been considered preferable to leave this species provisionally in the genus *Turbo,* in the absence of any more suitable generic position.

The neotype selected is 31.5 mm. high and 31.8 mm. broad. It possesses 4 rounded spiral ribs on the penultimate and 11 similar ones on the body-whorl.

Kaawatina gen. nov.

Type: *Kaawatina turneri* n. sp. (Figs. 65 and 66).

This new genus is based on two tiny shells shewing superficial resemblance to *Brookula* and *Rissoa.* Its relationships possibly are with the latter genus. Both specimens belong to the same species, and the heavy nature of their shells suggests that they are adults.

The type is the smaller of the two (1.6 mm. × 1.2 mm.) and shews a remnant of the nucleus, whilst the paratype (width 1.5 mm.), which has a broken spire, shews spiral ornamentation not visible in the holotype.

Shell pyriform, solid, with 3 very rapidly increasing whorls. Spire conical, a little shorter than aperture; outline of whorls fairly sharply convex. Aperture broadly ovate-pyriform; peristome entire and continuous, separated from parietal wall by a shallow crescentic groove. Outer lip rounded, heavy. Inner lip oblique, slightly arcuate. Elongated umbilical chink,

Uppermost whorl worn and broken, but apparently smooth; its shape suggests that it probably was not part of protoconch. Two lower whorls are crossed by axial costae (10 on body whorl) oblique to the right at an angle of about 45° and very heavy and blunt, giving shell a corrugated effect. Interspaces of costae on paratype shew strong regularly-spaced spiral ribs, 10 in number at the outer

lip, which pass from axial to axial, though without surmounting them, and also produce a corrugated effect.

The genotype is named after Mr. F. J. Turner, of Otago University.

Melanopsis trifasciata Gray.

Finlay (*loc. cit.*, p. 380) has noted that Neozelanic shells of this genus differ from the European form on which the genus *Melanopsis* was founded, and has proposed *Zemelanopsis* n. gen. to replace this latter for New Zealand shells. It is regrettable that no criteria are set forth whereby this proposed genus can be separated from European forms, especially in view of the occurrence of related species in the mid-Pacific (New Caledonia) at the present time.

It is considered preferable to retain the earlier generic name until this omission is rectified.

Turritella cf. **Huttoni** Cossman.

Marwick (MS.) notes the divergence of the *Turritella* previously listed as *T. huttoni* Cossm. (Bartrum, 1919, a) from that species, and remarks that it is undesirable to institute new species until a revision of the group has been effected. The Kaawa specimen, in any case, is too imperfect to serve as the sound basis of a new species.

Struthiolaria arthritica n. sp. (Figs. 55 and 56).

This species is related to *S. callosa* Marwick (*Trans. N.Z. Inst.*, vol. 55, 1924, pp. 182-3), and is represented by fairly numerous specimens in various stages of growth at Kaawa Creek. It differs from *callosa* in the feeble development of lower row of nodules on body-whorl, and in its broader, less definite spread of callus on parietal wall and inner lip, without the defined margin or abrupt edge shewn by *callosa.*

Shell fairly large, oval, with spire about height of aperture. Spire-whorls broadly angular, with a keel at middle. Body-whorl bi-angulate, with lower angle rather poorly developed and carrying occasional swellings which indicate obsolete earlier tubercles. About 8 or 9 strong tubercles on keel of body and antepenultimate whorls.

Spiral sculpture of fine regularly-spaced threads which are a little fainter on body-whorl than on spire. Aperture as in *S. callosa,* but callus is less thickly spread on inner lip, though it there forms a thick round pad about the middle and also a rounded knob reaching from posterior siphonal notch to a little above the angle, with a slight channel against the somewhat flat shoulder. Protoconch incomplete. Dimensions of holotype (apex missing): Height, 56.5 mm.; breadth, 44 mm.

Struthiolaria pseudovermis n. sp. (Figs. 63 and 64).

Represented by a single fairly small specimen. Solid ovate shell of the *vermis* group, closely resembling *S. vermis* itself and *S. nana* Marwick (*Trans. N.Z. Inst.,* vol. 56, 1926, p. 318) in form, but differing in detail of ornamentation.

Spire-whorls obtusely angled, becoming more convex towards apex; a keel on the angle, bearing traces of faintly-developed close-spaced small nodules, which grow progressively stronger until they

are quite prominent on body-whorl as outer lip is approached, though absent on lower rounded keel of this latter whorl.

Suture abutting; not broadly and deeply excavated as in *vermis*. Shoulder of whorls very slightly convex to flat on upper whorls, but becoming slightly concave on lower whorls owing to development of the tubercles at the angle.

Peripheral area of body-whorl slightly concave owing to absence of middle spiral carina characteristic of *vermis*.

Spiral sculpture: lirae rather faint on whorls, but stronger on base, which has about 6 irregularly-spaced threads. Aperture, columella and outer lip as in *S. nana*, though the callus of inner lip, whilst thin on parietal wall, thickens near posterior siphonal notch and spreads to half-way between keels of body-whorl. Protoconch absent.

Dimensions of holotype: Height, 40 mm.; breadth, 25.5 mm.

Struthiolaria illepida n. sp. (Fig. 62).

A large rather thin shell, elongate-oval in form. resembling *S. papulosa* (Martyn) but proportionately taller, whilst its tubercles are more distant, there being 11 per whorl in the new species compared with 13 to 18 in *papulosa*. Spire turretted, tall, nearly 1½ times the length of the aperture; spire-whorls strongly angled about the middle with prominent nodular keel and slightly concave shoulder.

Body-whorl has also lower rounded keel proceeding from just above suture, but without tubercles. Peripheral space between keels concave; this space is nearly flat in *papulosa*, for lower keel is poorly developed. Spiral sculpture of regular lirae. fairly strong on spire-whorls, but fainter on body-whorl, except on base.

Aperture incomplete; outer lip broken away. Columella concave, the beak bent to the right and slightly advanced. Callus of inner lip very thinly though broadly spread; extends as a thin smear to upper nodular keel. Protoconch absent. Holotype (the only specimen) incomplete; 61.5 mm. high.

Neojanacus kaawaensis n. sp. (Figs. 16, 17, 18, 19).

Though the shells included here shew certain important variation from the genotype of *Neojanacus*, they are provisionally included in that genus for want of a better allocation. The chief points of divergence are the slight displacement of the apex from its terminal position in the Recent species, and the development, on the posterior lower surface, of a ridge which simulates the early stage of development of the basal plate of *Crypta* (= *Crepidula*).* This is especially the case in juvenile, but less so in more mature forms.

In the new species the holotype which is judged to be a relatively mature shell, is a flattened very slightly elevated shell quadrate in outline, though the juvenile paratype is rounder and more convex. The apex is near, but not at, the posterior margin and consists of about 1½ spirally-coiled smooth whorls.

Shell smooth, with faint concentric lamellar imbrication towards margins. Muscle-scars indistinct, but apparently horse-shoe shaped, open towards the front.

*This appears also in juvenile shells of the Recent species of *Neojanacus*.

Dimensions of holotype (Figs. 16 and 17): Length, 6 mm.; breadth, 6.7 mm.; diameter of paratype, 3.2 mm.

Hipponyx sp. (Fig. 33).

Powell (*N.Z. Journ. Sc. and Tech.*, vol. 6, 1924, p. 284) shews that the shell recorded by Bartrum (1919, a) is not *antiquatus*, but a separate species.

Until better material than the present solitary specimen is available, however, it is undesirable to describe the shell as a new species.

Zegalerus crater Finlay.

The species recorded by Bartrum (1919, a) as *Calyptraea maculata* (Q. and G.) proves to be identical with that described by Hutton as *Trochita alta*. Finlay (*Trans. N.Z. Inst.*, vol. 57, 1926, pp. 391-2) discusses New Zealand calyptræids, referring several types to the genus *Sigapatella*. Others, however, with which *Trochita alta* is provisionally included, are referred by Finlay to a new genus *Zegalerus*. Radular characters (presumably determined by Finlay) separate this genus from *Sigapatella* and ally it to *Galerus* Humphrey (= *Calyptraea* Lamarck, 1799), from which, however, it is distinguished by conchological differences, which are not, however, specified by Finlay.

The specific name *alta* proves to be preoccupied, so that the shell *Trochita alta* Hutton now becomes *Zegalerus crater* Finlay (*loc. cit.*, p. 392).

Genus Crypta.

Finlay (*Trans N.Z. Inst.*, vol. 57, 1926, p. 393) shews that the genus name *Crypta* has priority over *Crepidula*, and, apparently on the basis of anticipated differences in the radulae of New Zealand shells from those of crepidulids of other areas, creates a new genus *Maoricrypta*.

The new name may well wait substantiation by further work and in the meantime the generic name *Crypta* be used.

Crypta turnialis n. sp. (Figs. 23 and 24).

The crepidulids from the Kaawa beds recorded previously by Marwick (*N.Z. Geol. Surv. Bull.* No. 28, 1926, p. 57) as *Crepidula wilckensi* Finlay (replacing *C. incurva* Zittel) and by Bartrum (1919, a) as *C. monoxyla* (Less.) and *C. gregaria* Sow: prove to belong to the one species which is now determined as new.

This new species approaches *Crypta wilckensi* (Finlay) very closely but differs in having a smoother surface, and in the beak. This latter is narrower, less inflated, less strongly incurved and less distant from the shell margin than in *wilckensi*, whilst it is oblique towards the anterior margin. This is noticeable even on specimens which have been on a flat surface, and very distinct on those from such locations as the columella of a large gasteropod. Septum somewhat concave, its free margin entire, straight near middle and curving at sides.

Dimensions of holotype: Length, 31.5 mm.; breadth, 19.25 mm.; thickness, 11.6 mm. Paratype: 31.5 mm x 12.0 mm. x 11.6 mm.

Crypta opuraensis n. sp. (Fig. 25).

This species is a narrowly arched oval-elongate crepidulid closely approaching *C. densistriata* (Suter) but coarser in ribbing. Beak slightly incurved; strongly twisted anteriorly. Septum nearly flat, its free margin apparently entire and only slightly curved. Sculpture of radial ribs, causing undulation of concentric growth-lines, 17 on posterior half; on anterior half a wide dorsal space with ribs only indistinctly shewn, then 5 strong ribs on ventral portion of anterior slope near the beak. Protoconch smooth, strongly incurved. Dimensions (approximate): Length, 25 mm.; width, 15 mm.; thickness, 9 mm. Holotype imperfect.

This is the shell recorded by Bartrum (1919, a) as *Crepidula striata* (Hutt.).

Family NATICIDAE.

Finlay (*Trans. N.Z. Inst.*, vol. 57, 1926, p. 394) has shewn that the generic name *Cochlis* must replace *Natica* for New Zealand shells, whilst Marwick (*Trans. N.Z. Inst.*, vol. 55, 1924, pp. 545-579), in a revision of the *Naticidae* of New Zealand, has followed Hedley (*Rec. Austr. Mus.*, vol. 14, No. 3, 1924, p. 154) in replacing the generic name *Polinices* by *Uber*.

The Kaawa *Naticidae* include:—

Cochlis notocenica (Finlay), (see Finlay, *Trans. N. Z. Inst.*, vol. 57, 1926, p. 394) which in part replaces Bartrum's (1919, a) record of *Natica zelandica* Q. and G. This species has previously been recorded only from the Oamaruian, but the Kaawa specimens are indistinguishable from topotypes from Awamoa.

Cochlis cf. *haweraensis* (Marwick). This is apparently a new species represented by one of two shells identified by Suter for Bartrum as *N. zelandica* Q. and G. It is, however, too imperfect to warrant description.

Uber kaawaensis Marwick.

Uber propeovatus Marwick. This species is very abundant at Kaawa Creek. Here also should be included the earlier record of *Polinices sagenus* Suter and probably *P. amphialus* (Watson), though the shell on which this determination was based by Suter is rather too imperfect for exact determination.

Xenophalium kaawaensis n. sp. (Figs. 53 and 54).

Iredale (*Rec. Austr. Mus.*, vol 15, No. 5, Ap. 6, 1927, pp. 333 and 339) introduces the genus names *Xenophalium* (p. 333) and *Xenogalea* (p. 339) for certain Australian helmet shells, but Powell in a paper in preparation shews that the two proposed genera are synonymous, so that *Xenophalium* takes page priority over *Xenogalea*.

The Kaawa species referred to this genus appears to be ancestral to the Waipipi representative of the *pyrum* line—*Phalium fibratum* Marshall and Murdoch (*Trans. N.Z. Inst.*, vol. 52, 1920, p. 131)—whilst *Phalium grangei* Marwick (*Trans. N.Z. Inst.*, vol. 56, 1926, p. 319) in its turn is a forerunner of the Kaawa species.

Finlay (*Trans. N.Z. Inst.*, vol. 56, 1926, pp. 230-31), includes *grangei* in his new genus *Euspinacassis*, but the fasciole of this species is sculptured transversely, as in *pyrum*, and lacks the longitudinal sculpture of *Euspinacassis*, true *Phalium* and *Semicassis*. For this reason *Phalium grangei* Marwick should be relegated to *Xenophalium*.

Description of Kaawa species:

Large inflated shell, with low conical spire, closely resembling *X. grangei* (Marwick).

Earlier spiral-whorls almost flat in outline, later ones slightly convex; body-whorl slightly concave above the broadly-rounded nodular shoulder-angle, but below this, swollen above and rapidly contracting towards base.

Suture bordered below by a low spiral fold with three strong spiral threads beneath on shoulder. Fasciole and outer lip broken away. Inner lip has expanded callus extending to the nodular shoulder-angle of body-whorl, thin on parietal wall but thicker below and practically closing false umbilicus. Columella callus smooth and fairly thick near base. Columella has 2 oblique folds near base, not 1 as in *grangei*.

Ornamentation differs from that of *grangei* by having two strong nodular cinguli and an inconspicuous third on body-whorl, in place of three and an inconspicuous fourth, whilst intermediate sculpture is very much stronger. Spire shews only one nodular spiral as in *grangei*. Between each pair of nodular cinguli, there are two smaller similar bands separated by shallow narrow interspaces. Below the lowest, or third, nodular cingulus there are 13 similar rounded spiral ribs separated by narrow grooves. Protoconch worn.

Dimensions of holotype: Height, 67 mm.; breadth, 48 mm.

Genus ODOSTOMIA Fleming, 1813.

Several damaged specimens were collected representing two species of this genus, one being illustrated in Fig. 32. A single specimen agrees closely with Suter's description of *O. sherriffi* Hutton (*N.Z. Geol. Surv. Pal. Bull.*, No. 3, 1915, pp. 16-17), except that the peripheral spiral sulcus is absent, perhaps as a consequence of wear.

Verconella koruahinensis n. sp. (Figs. 59 and 60).

Species of moderate size near *V. adusta* (Phil.). Only one specimen known. Fairly large, fusiform shell, with conical spire half the height of aperture and canal. Body-whorl with rounded shoulder-angle bearing rather distant rounded nodules present also on spire-whorls. Nodules regularly increasing and almost spinose on body-whorl; without the connecting carina present in *adusta*. Axial costae only faintly developed.

Aperture, columella, inner lip, and anterior canal as in *adusta;* columella broken below. Outer lip thin, not crenulate as in *adusta*, owing to finer sculpture. Posterior canal narrow, as shoulder of body-whorl is appressed towards suture. Suture appressed, somewhat deep; undulating on account of position immediately below nodular carina.

Ornamentation of numerous spiral lirae (very much finer than in *adusta*) with intervening still finer secondary threads, varying in number from 1 to 5—generally 1 on spire whorls and 4 or 5 on body-whorl.

Dimensions of holotype: Height (apex broken), 71.4 mm.; approximate breadth, 36.5 mm.

Genus AUSTROFUSUS Kobelt, 1879.

Finlay (*Trans. N.Z. Inst.*, vol. 56, 1926, pp. 232-3) shews that the generic name *Austrofusus* replaces *Aethocola* Iredale, and also institutes a new genus *Zelandiella*, based on *Neptunea nodosa* Hutton as type, in which he includes, amongst other species, the Kaawa shell *Siphonalia propenodosa* Bartrum. Considerable diagnostic importance is placed by Finlay on the characters of the protoconch.

Examination of reasonably well preserved protoconchs in 8 or 9 specimens of *propenodosa* fails, however, to bear out Finlay's classification. One apical specimen, in particular, quite indistinguishable in sculpture from *propenodosa*, shews a conic protoconch like that of *Austrofusus glans* (Bolten). (See Finlay, *Trans. N.Z. Inst.*, vol. 56, 1926, p. 232), as is illustrated by Fig. 67

For this reason, the present writers prefer to relegate *propenodosa* to the genus *Austrofusus*. Regarding the shells described as *Siphonalia kaawaensis* by Bartrum (1919, b), both Marwick (MS.) and Finlay (*Trans. N.Z. Inst.*, vol. 56, 1926, p. 233) have regarded these as identical with *propenodosa*; further collecting has substantiated this view.

Concerning the sub-genera of *Austrofusus*, it may be remarked that there is very unequal development of the fascioles of specimens of *A. glans* (Bolten) from Kai Iwi, some being even imbricating and possessing a slight keel. Further, a Recent *A. glans* colony from Opotiki shews variable twisting of the pillar and some inequality of development of the fasciole; in one or two specimens it is well developed.

In the sections *Neocola* and *Nassicola*, however, the differences of length of the canal are so marked as to be very useful criteria.

Austrofusus (Neocola) ngatuturaensis n. sp. (Figs. 57 and 58).

This species resembles *A. taitae* (Marwick) and also shews possible alliance to *A. gamma* Finlay.

Shell moderately small, fusiform with conical spire stepped on account of strongly angled whorls and a little less in height than aperture and canal. Six or seven whorls with high, fairly smooth protoconch (about 3½ whorls) shewn moderately well on paratype. Whorls concave on shoulder, with suture margined by 2 close-spaced strong cords on narrow raised shoulder, and corrugated as result of strong axial costae. Costae faint on excavated shoulder and raised into sharp tubercles on angle, though dying away gradually on base. Earliest spire-whorls convex, later ones have angle-keel about middle. Body-whorl also with faintly nodular lower keel giving more definite bi-angular outline than in *taitae*.

Aperture oval, oblique, narrowly notched above on account of appressed shoulder, and angled about middle. Outer lip thin and

with strong transverse lirae within. Inner lip thin and narrowly limited. Columella has greater twist to left and back than in typical *Austrofusus* with very narrow and only slightly raised marginal keels to fasciole.

Spiral ornamentation of strong approximately equidistant, sharply-raised lirae surmounting the costae and their nodular extensions, and generally with 1, sometimes 2, or, on the base, even more, subsidiary threads in the interspaces. Two close-spaced lirae, with a fairly strong intermediate secondary, make a distinct keel at the shoulder-angle, whilst the lower keel of the body-whorl has a single strong spiral rib.

The central basal area has 3 or 4 strong spiral cords, with the usual intervening secondary threads, and is inclined to be finely nodular. Below these there is similar, but less prominent spiral sculpture. Oblique growth-lines may produce a faint reticulation with the spiral lirae.

Dimensions of holotype (incomplete): 24 mm. x 14.8 mm. Paratype: 23 mm. x 13 mm.

Cominella facinerosa n. sp. (Figs. 26 and 27).

Strongly inflated, fusiform shell with conical spire about half the height of aperture and canal. Worn and imperfect; apex and much detail of spire-whorls missing. Body-whorl broadly convex in outline; swollen above and rapidly contracting towards a broad fasciole at the neck. Shoulder conforming with slope of spire; lower margin defined by uppermost of narrow rounded spiral cinguli prominent on body-whorl. Aperture oval, oblique, channelled narrowly above and produced below into a broad short anterior canal bent distinctly to left and back, and moderately deeply notched.

Inner lip appears to be narrowly and lightly calloused above but callus is thickened upon the sinuous columella, and here forms a plate which gradually tapers to a sharp beak below, and covers a tiny false umbilicus wedged in against the fasciole.

Sculpture spiral; worn from spire. Shoulder of body-whorl appears to have been almost smooth; below this 12 fairly strong equidistant, rounded cinguli, separated by shallow grooves equal in width to the cinguli. Occasional abnormally developed growth-lines produce irregular local minor lamellation.

Dimensions of holotype: Height, 29 mm.; width, 20.5 mm.

Alcithoe propearabicula n. sp. (Fig. 61).

A small elongate-oval solid volutid with height of conical spire (broken) about half that of aperture. Whorls with fairly numerous faint axial ribs; 13 to 15 on penultimate whorl and 10 on body-whorl. Whorls very obtusely angled the angle of spire-whorls near lower suture. Axial costae nodular at angle and extending from suture to suture in spire-whorls; gradually diminish on body-whorl until become almost obsolete near outer lip. Body-whorl tapers gradually from angle to neck, where remains of fasciole are imperfectly visible.

Aperture oblique, broad. Outer lip broken below, reflexed and thickened at margin; upper portion locally envelops the angle-nodules, extending to middle of shoulder, and forms a massive broadly-rounded projecting shoulder which encloses a wide, elongated

posterior canal. Inner lip very thinly but broadly smeared with callus, which thickens below and tapers to a point. Columella straight above and with 4 strong wide-spaced oblique plaits, but twisted slightly to left and back at the beak.

Differs from *arabicula* in more numerous costae on spire-whorls and lower position of the angle of these whorls.

Dimensions of holotype (incomplete): Height, 32.8 mm.; width, 17.8 mm.

Baryspira cf. **hebera** (Hutton).

Kaawa specimens resemble *hebera,* though they were not compared with a series of topotypes (Awamoa).

Baryspira exsputa n. sp. (Figs. 28 and 29).

This new species contains the shells previously recorded from the Kaawa beds by Bartrum (1919, a) as *Ancilla novae-zelandiae* (Sow.), though Marwick (see Henderson and Grange, *N.Z. Geol. Surv. Bull.* No. 28, 1926, p. 57) has realized the possibility of their representing a new species.

The Kaawa species is relatively small but is otherwise so closely similar to *novae-zelandiae* that a record of divergent characters will suffice. The essential difference lies in the shorter spire and more inflated body-whorl. In addition, the basal grooves are higher up in the new species.

Dimensions of holotype: Height, 5.7 mm.; breadth, 2.8 mm.

Marginella hesterna n. sp. (Figs. 30 and 31).

The Kaawa species of *Marginella* approach closely to the Recent New Zealand *pygmaea*, but differ in the smaller average adult size, the blunter nature of the spire and the very much thicker outer lip.

It is probable, in any case, that true *pygmaea* is not represented in New Zealand. The type appears to be from Brisbane, for Tomlin remarks (*Proc. Mal. Soc.*, vol. 12, 1917, p. 293) that '. . . . the type is the larger of two on one tablet; the smaller is labelled "Brisbane M.C." ', and Australian shells appear to be narrower and more cylindrical than New Zealand ones.

The Kaawa shells average about 4.5 mm. in height, whilst a series of Recent "*pygmaea*" specimens from Whangaroa average 7 mm., though Suter (*Manual,* p. 465) records the height of shells from Foveaux Strait as 5.5 mm.

The Kaawa species is a small, very solid, smooth volutiform shell with a low blunt spire one-fifth the height of aperture. Protoconch low, smooth, about 1½ whorls, followed by 3½ convex whorls, the last, or body-whorl, much inflated with a broad convex shoulder, and then tapering fairly rapidly to the base. Aperture long, fairly straight and slightly oblique; wedge-shaped, channelled and narrow above but widening below. A broad shallow anterior notch at base, but without resulting fasciole. Outer lip greatly thickened, slightly reflexed; continues as a sharp ridge or varix across base just above notch. Columella straight and slightly oblique to the left; carries 4 strong, sharp, equidistant plaits near the base, the upper two nearly transverse, the lower pair more oblique. Inner lip polished and ill-defined.

Dimensions of holotype: Height, 4.5 mm.; width, 2.8 mm.

Marginella (?) **harrisi** Cossm.

The record of *M.* (?) *harrisi* Cossm. (Bartrum, 1919, a) is incorrect, for the shell on which it was based is probably an imperfect specimen of the new species.

Genus AUSTRODRILLIA Hedley, 1918.

Hedley (*Rec. Austr. Mus.,* vol. 13, No. 6, 1922, p. 250) has proposed to put *Drillia laevis* (Hutt.) into a new subgenus *Splendrillia* of the genus *Melatoma* Swainson—type *Drillia woodsi* Beddome. W. L. May (*Illustr. Index Tasm. Shells,* 1923, pl. 35 Fig. 15) refers *woodsi* to the genus *Austrodrillia* Hedley, 1918, so that *Splendrillia* becomes a synonym of this latter genus, and the Kaawa shell previously listed as *Drillia laevis* (Hutt.) must be referred to *Austrodrillia.*

Certain Kaawa shells of the original collection identified previously as *Drillia aequistriata* Hutt. prove to belong to a new species of *Austrodrillia* now described below.

Austrodrillia koruahinensis n. sp. (Figs. 36 and 37).

A shell very closely resembling *aequistriata,* but more densely striated. Fairly large turreted shell, with sharp conical spire a little higher than aperture and canal. Seven whorls; whorls deeply excavated on shoulder and gently convex below. Protoconch (paratype) about 1½ convex, smooth whorls. Suture impressed and margined below by a slightly convex raised spiral band, which descends into the concave sinus-area of shoulder. Outer lip broken; evidently a deep notch in outer lip near suture, for growth-lines are bent sharply and strongly back. Aperture slightly oblique; columella straight above and bent slightly to left near fasciole at base. Anterior canal (paratype) short and fairly broad; rather shallowly notched, so that fasciole is not prominent. Inner lip sharply margined; rather narrowly calloused, with somewhat thick pad of callus at posterior canal.

Sculpture: 11 or 12 axial costae passing up from suture to the slight angle at shoulder, but not developed on the latter; inclined to be faintly nodular at angle, especially on upper whorls. Spiral ornamentation of close-spaced threads (about 9 per mm. on body and penultimate whorls). Base has about 11 larger sub-equidistant spiral threads (including those on fasciole) less prominent towards shoulder. Paratype has 6 raised threads on base and 5 on fasciole.

Dimensions of holotype (Fig. 36) (apex broken): Height, 23.7 mm.; diameter, 8.8. mm. Paratype: 18 mm. x 6.3 mm.

Austrotoma cf. **scopalveus** Finlay.

Kaawa specimens agree moderately closely with Finlay's species (*Trans. N.Z. Inst.,* vol. 56, 1926, p. 253). This applies particularly to a single juvenile shell, though the adults appear to attain a greater size than the type, whilst the body-whorl appears to be more loosely coiled, and, on smaller typical specimens, exposes 6 spirals on the penultimate whorl.

Turris cf. **duplex** Suter.

The shell recorded by Bartrum (1919, a) as *Turris duplex* Suter differs from this latter species in the number of ribs and in the possession of some larger spiral threads on the base. The canal is unknown, for the outer lip is broken. As only one specimen is known, its divergence from *duplex* scarcely seems sufficiently marked to warrant the creation of a new species.

Guraleus ngatuturaensis n. sp. (Figs. 34 and 35).

The new Kaawa species is closely allied to *G.* (= *Mangilia*) *sinclairi* (Smith) (see Hedley *Suppl. to Journ. Roy. Soc. N.S.W.*, 1918, p. M 79), but has its axial ribs finer and more numerous—about 21 on body-whorl, in contrast with 10—16 in *sinclairi.*

Fairly small, turreted, fusiform, axially costate shell, with conical spire about 4/3rds height of aperture and canal. 6 convex whorls; shoulder slightly convex to almost flat on spire-whorls, and flat to slightly concave on body-whorl. Spire-whorls angled near middle, but shoulder of body-whorl narrow. Protoconch low, about 1 smooth whorl, followed by a whorl which is spirally lirate, but not axially costate. Subsequent whorls have both spiral and axial sculpture. Suture impressed. Aperture oblique to left, oval, with a distinct angle above and a fairly broad and somewhat short canal below, oblique to left and not notched at base. Outer lip broken. Inner lip thin smooth and narrow. Columella broadly convex, oblique to left.

Sculpture: Axial costae from suture to suture on spire, weaker on shoulder of body-whorl, and gradually dying out on base. Costae narrow, sharply raised; interspaces a little wider than ribs. These latter almost straight on lower half of each whorl, but bent distinctly to left on shoulder forming a shallow V with apex at angle. Close-spaced strong spiral threads (about 12 per mm. on penultimate whorl) prominent, surmounting costae; wider apart and stronger on base.

Dimensions of holotype: Height, 7.1 mm.; width, 2.6 mm.

Genus PERVICACIA Iredale, 1924.

Terebra benesulcata Bartrum and a shell in the A.U.C. collection identified by Dr. Marwick as *T. tristis* Desh. should now be referred to the genus *Pervicacia* Iredale (*Proc. Linn. Soc. N.S.W.*, vol. 49, pt. 3, 1924, p. 262).

Fresh material shews that while *tristis* is certainly represented by a single specimen, others previously referred to this species belong to a new species now described as *Pervicacia subtilissima* n. sp.

Pervicacia subtilissima n. sp.

Elongated sharply turreted axially costate shell close to *tristis*. Spire four times height of aperture and canal; outline fairly straight. Whorls only slightly convex, 9 on holotype, 6½ on paratype. Body-whorl convex, rapidly contracting to neck. Aperture (paratype) oval, oblique to left, terminating below in short, broad canal bent strongly to left, and moderately deeply notched, giving rise to an oblique wide fasciole bordered by high ridge against base of body-

whorl. Columella straight above, bent to left below. Inner lip narrow and thin. Protoconch (paratype) 3½ or 4 smooth whorls.

Axial ribs not so flexuous as in *tristis*, more upright and much sharper or narrower at crest; 15 ribs on antepenultimate whorl.

Dimensions of holotype (incomplete): Height, 18.8 mm., diameter, 5.4 mm. Paratype: 10 mm. x 3.2 mm.

Genus RHIZORUS Montfort, 1810.

Finlay (*Trans. N.Z. Inst.*, vol. 57, 1926, p. 437) points out that Hedley (*Proc. Linn. Soc. N.S.W.*, vol. 41, 1917, p. 716) indicated that the generic name *Volvulella* Newton, 1891, must be replaced by *Rhizorus* Montfort, 1810. At the same time he shews that the New Zealand Recent shells grouped by Suter (*Manual*, p. 529) with the fossil species *Volvulella reflexa* (Hutt.) are distinct from this latter, and institutes a new species *nesentus* to include them.

Two specimens collected from the Kaawa beds differ both from the Recent and the fossil species and constitute a new species.

Rhizorus marwicki n. sp. (Figs. 40 and 41).

Only a single worn specimen (the holotype) now remains, for the small paratype was accidentally destroyed subsequent to examination.

A tiny, elongate-oval, involute shell with sharp apex and rather narrowly rounded base. Close to *reflexa* and *nesentus*, but more tumid than either. Outer or body-whorl broadly convex, narrowing rapidly above to a fairly sharp spire, but more gently below to the narrowly curved base.

Shoulder slightly concave in front, near base of spire; equator of body-whorl about one-third height down from apex. Aperture the whole length of shell; a narrow slit above, but swelling below in accord with narrowing of body-whorl at parietal wall. Outer lip thin, broadly convex, broken above; apparently not reflexed; bent sharply around to join with almost straight short pillar at base. A small chink-like hollow between pillar and initial tumescence at base of body-whorl.

Ornamentation: Strong close-spaced axial striae shewn well by broken paratype, but worn from holotype except at inner lip. Faint traces of about three spiral grooves shewn near base of paratype.

Dimensions of holotype: Height, 2.4 mm.; diameter, 1.35 mm.

Genus CYLICHNINA Monterosato.

Finlay (*Trans. N.Z. Inst.*, vol. 57, 1926, p. 438) shews that this generic name must replace *Cylichnella* for many New Zealand species.

Genus DENTALIUM Linné, 1758.

In the absence of better material than is available, no revision of the Kaawa species of this genus has been attempted.

Nucula ambrosia n. sp. (Figs. 42 and 43).

The shells recorded by Bartrum (1919, a) and Marwick (see Henderson and Grange, *N.Z. Geol. Surv. Bull.* No. 28, 1926, p. 57)

as *Nucula hartvigiana* Pfr. differ from this species in many respects, though undoubtedly closely allied to it, and are therefore given specific rank. In outline the posterior margin is flatter, the flattening beginning higher up, for the hinge is shorter than in *hartvigiana.* In addition, the radial sculpture is more definite, and there are only 7 concentric ribs per mm. compared with 9 in *hartvigiana.* Finally, in the hinge, the ligament pit is smaller, narrower, and more oblique, whilst the posterior teeth do not come so far down as in *hartvigiana,* for they number only 6 instead of 8 or 9.

Shell, small, obliquely subtriangular, highly inequilateral, thin and with pearly interior; ornamented by radial striae and concentric ribs. Beaks small, strongly incurved, approximate, directed back; situated at one-fourth length from posterior end.

Broad shoulder-like folds from beaks to anterior and posterior margins. Anterior dorsal margin sloping, gently convex, with faint sinuosity immediately behind where anterior fold meets margin. Posterior margin then joins with ventral margin in regular convex curve.

Hinge broadly arched, with central, narrow, elongate resilium pit strongly oblique anteriorly. 6 sub-equal transverse teeth behind pit; about 10 in front, becoming smaller and indistinct towards pit. Interior of shell pearly; strong close-spaced striations near basal margin; this latter finely crenulate.

Ornamentation of strong equidistant concentric ribs (7 per mm.) with sub-equal intervening furrows; both crossed by very dense radial striae, especially prominent in furrows.

Dimensions of holotype: Length, 5.1 mm ; height, 2.8 mm. thickness, 1.2 mm.

Nuculana tenellula n. sp. (Figs. 3, 4. and 5).

Dr. Marwick has pointed out (MS.) that the *Nuculana* listed by Bartrum (1919, a) as *Leda bellula* A.Ad. is slightly different from that species in that its posterior dorsal surface is more concave, its beak blunter and more upturned, whilst its teeth are fewer and extend less towards the posterior margin or beak. The shells are therefore separated out as a new species named as above.

This new species is a small, strongly inequilateral, concentrically ribbed shell, ovate in form, rounded in front and produced narrowly behind to a rounded slightly uptilted beak. Umbones small, approximate, situate at anterior third, directed back, with an escutcheon separated from rest of posterior dorsal surface by a distinct fold running from umbones to posterior margin. Escutcheon without concentric markings. Posterior dorsal outline concave with a sharp ridge in middle of escutcheon produced by sharply upturned shell margins; descending very slowly. Ventral margin broadly convex from beak at posterior margin and forming a fairly uniform curve with anterior and anterior dorsal margins.

Teeth transverse, V-shaped: 14 on anterior side, reaching to anterior margin, 10 on posterior side extending little more than half way to beak. Teeth decrease in size towards umbo.

Ornamentation of strong, fairly sharply raised concentric ribs, closer together near beaks than towards middle of shell, and angled at narrow posterior fold; about 6 per mm.

Dimensions of holotype: Length, 6.7 mm.; height, 4 mm.; thickness, 1.6 mm. Paratype, 8.4 mm. x 4.7 mm. x 1.8 mm.

Genus ARCA Lamarck, 1799.

Marwick (MS.) remarks on the divergence of the shell listed previously as *Arca subvelata* Suter from the type. As only two shells have been collected, however, and may represent juvenile forms, more material is required for comparison.

Other Kaawa species are *A. novae-zelandiae* Smith and a new species recognised as such originally by Dr. Marwick, which has been named *Arca (Acar) opuraensis* n. sp.

Arca (Acar) opuraensis, n. sp. (Fig. 15).

Known by a single left valve. Elongate, quadrate, ventricose, strongly inequilateral shell with strong concentric and radial ribs yielding imbricated sculpture. Broad swollen beak at about anterior third, from which a strong fold runs to posterior dorsal margin, delimiting posterior dorsal area, and a faint one, with a slight sinus above it, to anterior basal margin. Beak directed forwards, relatively approximate; cardinal ligament area almost obsolete, but a linear anterior area raised along anterior margin and a broad flattened posterior area. Anterior margin descends slowly; sinuous, a slight sinus near beak and then narrowly convex towards prominent angle with sub-vertical sinuous anterior margin. Ventral margin forms strong rounded angle anteriorly, flexed, with an anterior gape, lightly convex. Posterior dorsal margin horizontal, straight. Posterior lateral margin somewhat oblique towards basal margin, lightly concave in middle, strongly and broadly angled above and more narrowly below.

Sculpture reticulated. About 15 very strong rounded concentric ribs, closer together near beaks and more distant below, where lowest 3 or 4 have rather an imbricated structure. Also strong radials, about 3 per mm., developed generally between concentric ribs and dying out on these latter, except towards ventral margin where they cause a crenulation of the concentric sculpture which is especially prominent on posterior area. Grooves between radials subequal to these latter.

Hinge-plate narrow, worn; teeth straight, in oblique series, large, not numerous—about 12 posteriorly and 4 anteriorly—obsolete below beak. Internal margin worn, slightly sinuous, but apparently not crenate.

Dimensions: Length, 8.3 mm.; height, 4.8 mm.; thickness, 2 mm.

Glycymeris waipipiensis Marwick.

Bartrum's (1919, a) record of *G. striatularis* (Lamk.) should be amended. The species is *G. waipipiensis* Marwick. Similarly, Marwick (*Trans. N.Z. Inst.*, vol. 54, 1923, p. 72) has shewn that the record of *G. globosa* is incorrect, the shell being a new species—*G. kaawaensis* Marwick.

Cuna cerussata n. sp. (Figs. 46 and 47).

Dr. Marwick separated out a shell collected by Bartrum as the Recent *Cuna carditelloides* Suter, but comparison with topotypes of

that species (Figs. 44 and 45) shews many strong differences. The outline is more rounded, the posterior dorsal margin being broader, more regularly and strongly convex and not so rapidly descending as in *carditelloides*, the dorsal margin and umbo thus being broader. Further, there is no distinct angle near the posterior margin, whilst, as concerns sculpture, the ribs are much broader in the new species and the interspaces linear.

Shell minute, fairly solid, moderately ventricose, slightly inequilateral, radially ribbed, with fairly broad approximate central beak with distinct oval lunule in front.

Posterior dorsal margin as described; anterior dorsal margin sloping fairly steeply, flat above and then sweeping round in semicircular curve embracing ventral margin.

Sculpture of about 17 broad, flat, subequal, radial ribs (smaller near dorsal margin), with linear intervening grooves. Hinge-plate heavy. Holotype (right valve) shews stout slightly bifid cardinal tooth. Internal basal margin crenate.

Dimensions of holotype: Length, 1.7 mm.; height, 1.8 mm.; thickness, 0.55 mm.

Cardita aoteana Finlay.

Finlay (*Trans. N.Z. Inst.*, vol. 57, 1926, p. 459) shews that the species *C. calyculata* (L.) is not represented in New Zealand, and states that the Recent New Zealand shells fall in at least two species he institutes—*C. brookesi* and *C. aoteana.* The Kaawa shells listed previously as *calyculata* prove to belong to the species *aoteana.*

Genus VENERICARDIA Lamarck, 1801.

A number of species of this genus are represented at Kaawa, including *difficilis* (Desh.), *lutea* (Hutt.) and 3 new species of the *purpurata* group, whilst the record of *purpurata* itself must be expunged. The Kaawa specimens of *lutea* have the shape and hinge characters of typical *lutea,* though the ribbing is slightly closer than in the Recent species.

Venericardia koruahinensis n. sp. (Figs. 10 and 11).

Small, rounded-ovate, only slightly inequilateral shell, moderately ventricose, broader than high, and with strong radial ribs. Beaks small, little inflated, approximate, sub-central, fairly strongly curved and with a large oval lunule in front. Anterior end slightly the longer; less broadly rounded than posterior end. Anterior dorsal margin almost flat to gently convex, sloping very gradually to regularly rounded anterior margin. Ventral margin broadly rounded, continuing curves of lateral margins. Posterior dorsal margin gently convex; some paratypes have distinct angle at posterior margin.

No concentric sculpture, but about 22 close-spaced broad, rounded, radial ribs with equal interspaces.

Hinge as in *purpurata,* except that central cardinal of right valve is narrow. Internal basal margin rather coarsely crenulate.

Dimensions of holotype: Length, 6.5 mm.; height, 5.4 mm.; thickness, 1.8 mm. Paratype: 5.9 mm. x 4.6 mm. x 1.5 mm.

Venericardia (Pleuromeris) miniscula n. sp. (Fig. 12).

Very small, equilateral, sub-circular, moderately ventricose shell, with small poorly-inflated central beaks. Dorsal margin with gradual slope; moderately flat immediately behind beak, and then sweeping round to conform with narrow arc of posterior margin. Flattened, or slightly concave in front with a distinct angle shewn by some paratypes at rounded anterior margin. Basal margin semi-circular. Sculpture of about 22 narrowly rounded, close-spaced radial ribs, with equal interspaces. Faint growth-lines visible near ventral margin. Hinge of *Pleuromeris* type; worn on holotype. Basal margin (paratype) strongly and coarsely crenulate.

Dimensions of holotype: Length, 4.6 mm.; height, 4.6 mm.; thickness, 1.2 mm. Paratype: 3.2 mm. x 3 mm. x 1.05 mm.

Venericardia penerectangularis n. sp. (Figs. 8 and 9).

A fairly small, solid, ventricose, quadrate species with strong radial ribs; near *difficilis,* but more quadrate and with slight differences in the hinge.

Beaks about anterior fifth, broad, prominent and rounded with fairly small inset heart-shaped lunule in front. Posterior dorsal margin very gently convex, sub-parallel to ventral margin and strongly angled at posterior margin. The latter almost straight, sub-vertical, with a rounded-rectangular angle at basal margin. Basal margin flat to lightly convex, sloping gradually up to fairly sharply-rounded anterior margin. Anterior dorsal margin flat, or faintly concave, near beak, then descending steeply, gently convex, to anterior margin.

Sculpture (slightly worn) of about 20 strong, rounded, radial ribs with somewhat flattened crests and equal interspaces. Ribs rendered faintly nodular by imbricating development of growth-lines, which are prominent in interspaces as raised threads.

Hinge-plate heavy. Posterior cardinal of holotype (left valve) sub-parallel to dorsal margin; anterior cardinal small and broadly triangular. In right valve (paratype) central and posterior cardinals sub-parallel to dorsal margin. Hinge otherwise as in *difficilis.* Internal basal margin coarsely and strongly crenulate.

Dimensions of holotype (left valve): Length, 13.5 mm.; height, 10.5 mm.; thickness, 4.2 mm. Paratype (right valve): 13 mm. x 10.25 mm. x 4 mm.

Genus NOTOMYRTEA Iredale, 1924.

Finlay (*Trans. N.Z. Inst.,* vol. 57, 1926, p. 461) places shells previously recorded from the Kaawa beds as *Lucinida concinna* (Hutton) and *L.* cf. *levifoliata* Marshall & Murdoch in the new subgenus *Pteromyrtea* of the genus *Notomyrtea* Iredale *(Proc. Linn. Soc. N.S.W.,* vol. 49, pt. 3, 1924, p. 206). The Kaawa shells compared with *levifoliata* appear to agree well with that species.

Diplodonta zelandica (Gray).

Finlay *(loc. cit.,* pp. 461-2) wishes to dismiss *Diplodonta* from lists of New Zealand fauna, and replace it by *Zemysia* gen. nov., but

records no differences of the New Zealand shells from those classed in the genus *Diplodonta* elsewhere.

Rochefortula kaawaensis n. sp. (Figs. 51 and 52).

Finlay *(loc. cit.*, pp. 464-5) institutes the new genus *Rochefortula* to include the Recent New Zealand species *Rochefortia reniformis* Suter (*Trans. N.Z. Inst.*, vol. 40, 1908, p. 357) and predicts the discovery of Tertiary ancestors, one of which has now appeared from the Kaawa beds.

The solitary shell representing the new species has the characters of the right valve of *reniformis*, for its anterior end is the longer and its beak directed back, but differs from this latter species in having its ends more bluntly rounded, whilst the concentric lines are faint. Further, it declines more steeply at the posterior end, and the ventral margin is flattened.

Shell small, poorly-inflated, sub-quadrate, rounded; only slightly inequilateral, almost smooth, with small inconspicuous beak near the middle. Dorsal margins broadly convex; posterior margin slopes fairly steeply and is well rounded. Anterior margin descends more gradually and forms a broadly rounded angle at ventral margin. This latter flat at middle and then conforming anteriorly with strong sweep of rounded anterior margin.

Sculpture (slightly worn): Faint growth-lines and traces of dense weak radial striae, especially towards basal margin. These latter may not represent true sculpture, however, for shell is worn. Hinge (right valve) shews a fairly heavy hinge-plate with resilium pit below the beak and a strong divergent, raised cardinal on either side. Internal margin smooth.

Dimensions of holotype: Length, 6 mm.; height, 4.7 mm.; thickness, 1.3 mm.

Genus MACOMA Leach, 1819.

Finlay (*loc. cit.*, p. 435) states that the generic name *Tellina* s. str. is inapplicable to New Zealand species, and refers many of them to the genus *Macoma* Leach, 1819. Amongst Kaawa species of *Tellina* listed by Bartrum (1919, a) is *huttoni sterrha* based on Suter's determination of a single valve. The addition of fresh material shews, however, that this is a new species described below as *Macoma subtriquetra* n. sp.

The other species represented are *M. edgari* (Iredale) (= *glabrella*), *M. gaimardi* (Iredale) (= *alba*), *M. huttoni* (Smith) and *M. spenceri* (Suter). The species *Tellina urinatoria* Suter appears to belong to the new genus *Maoritellina* of Finlay (*loc. cit.*, pp. 465-6).

Macoma subtriquetra n. sp. (Figs. 1 and 2).

Unfortunately, all the specimens of this species are left valves and it is impossible to obtain the hinge-characters sufficiently clearly to determine whether or not the shell should be referred to the genus *Barytellina* Marwick (*Proc. Mal. Soc.*, vol. 16, 1924, p. 26). It is, however, very near *Macoma huttoni sterrha* (Suter), but differs from it in its smaller size and different outline.

Shell very small, thin, ovate to sub-trigonal, generally compressed, inequilateral; small, low, inconspicuous beaks near anterior third. Anterior end the longer, broadly rounded; posterior end much narrower. An indistinct fold runs from beak to angle of posterior margin. Anterior dorsal margin flattish above, descending steeply. Posterior margin strongly angled at basal margin. The latter broadly convex, though with a faint sinus behind.

One specimen, apparently of this species, shews a more rotund outline, combined with greater convexity.

Sculpture: Growth-lines developed into faint striae visible on parts of a paratype.

Hinge as in *huttoni.* Pallial sinus imperfectly visible. Internal margin smooth.

Dimensions of holotype: Length, 7.5 mm.; height, 5.7 mm.; thickness, 1.1 mm.

Semeloidea donaciformis n. gen. and sp. (Figs. 49 and 50).

A shell new to New Zealand, and puzzling in its relationships, for it has hinge-characters similar to those of *Semele,* but differs from that genus in outline and in coarsely crenulated ventral margin—features in which it resembles *Donax.*

The material available is a single, perfectly preserved left valve. It exhibits characters so distinct from those of all other genera known to the authors that its inclusion in any one of them—for example, *Semele,* which appears to be its closest relative—would be highly undesirable. As an alternative, the new genus *Semeloidea* has been created.

The genotype is a small, thin, almost equilateral, ventricose, sub-trigonal-ovate shell, with breadth greater than height. Beak small, sharp, directed forwards, situated at the middle. No lunule or escutcheon. Anterior and posterior ends rounded, the dorsal margins with a moderate slope and gently convex, the former slightly flatter than the latter. Basal margin horizontal, almost straight in middle.

Sculpture of microscopic concentric growth-striae, with strong radial rounded fold-like ribs prominent at the extremities, but rapidly becoming obsolete along ventral margin and also fading rapidly away towards upper half of shell. About 5 strong radial ribs at each extremity, with equal interspaces.

Interior grooved and marginally crenulated in correspondence with external sculpture. Adductor scars distinct, equal, circular. Pallial sinus not shewn, as surface is slightly etched. Hinge (left valve): 2 strong, raised cardinal teeth below beak, followed by a strong, long, gently curved posterior lateral sub-parallel to posterior dorsal margin. Anterior cardinal much the stronger, thickening below and directed obliquely forwards; the other sub-vertical, distinctly curved posteriorly.

Resilifer indicated by faint striations, sub-parallel to posterior lateral, visible in pit between it and cardinals.

Dimensions: Length, 7.9 mm.; height, 6 mm.; thickness, 1.9 mm.

Resania exoptata n. sp. (Figs. 13 and 14).

Known by only two specimens, both somewhat imperfect. Differs from Recent *R. lanceolata* Gray in possessing straighter dorsal surfaces and in the distinctly raised nature of posterior dorsal surface.

Fairly large, lanceolate, thin, slightly inequilateral, rather compressed shell with very small sharp beaks near the middle; sculpture of concentric growth-lines. Anterior end slightly the longer; posterior end with broad indistinct fold from beak to posterior margin. Posterior gape of valves.

Anterior dorsal margin straight with very gentle to obtuse angle with narrowly rounded anterior margin. Posterior dorsal margin almost flat, but with slight convex bulge not far from beak, where margin rises steeply from dorsal surface. Posterior margin broken away; growth-lines indicate that it is less narrowly rounded than anterior. Basal margin convex; only slight curvature.

Ornamentation of growth-lines; traces of original colour remain giving alternations of pale brown and darker purplish concentric bands of varied width.

Interior not visible.

Dimensions of holotype: Length, 26.5 mm.; height, 11 mm. Large paratype (imperfect) has approximate proportions (estimated) as follows:—Length, 62 mm.; height, 27 mm.; double thickness, 11 mm.

Tawera bartrumi Marwick.

In a recent revision of New Zealand *Veneridae*, Marwick (*loc. cit.*, pp. 614-615), relegates *Chione spissa, C. mesodesma* and *C. meridionalis* of Bartrum (1919, a) to *Tawera bartrumi* n. gen. et sp.

Gomphina (Gomphinella) maorum Smith.

Marwick (*loc. cit.*, p. 631) institutes the new subgenus *Gomphinella* to include this species.

Eumarcia kaawaensis Marwick.

Paphia curta (Hutton) of Bartrum (1919, a) is referred by Marwick (*loc. cit.*, p. 627) to this species.

Nemocardium finlayi n. sp. (Fig. 48).

Finlay (*loc. cit.*, p. 471) recommends the use of the genus name *Nemocardium* Meek, 1876, to cover *Protocardia pulchella* (Gray) and an ancestral Tertiary species *Nemocardium semitectum* Marwick (*Trans. N.Z. Inst.*, vol. 56, 1926, p. 312).

Better material than that previously available has shewn that the Kaawa species, previously recorded as *pulchellum*, differs from this shell and from *semitectum* in having much heavier flat-topped ribs, with only narrow interspaces, whilst the spines on the posterior slope are larger, blunter and more distant one from another. The new species is a thin, fragile, sub-circular, slightly inequilateral, strongly ventricose shell with strong close-spaced radial ribs. Beaks fairly large, tumid, slightly anterior. Dorsal margins descend in arcuate curve to lateral margins and join with them and basal margin in sub-circular curve.

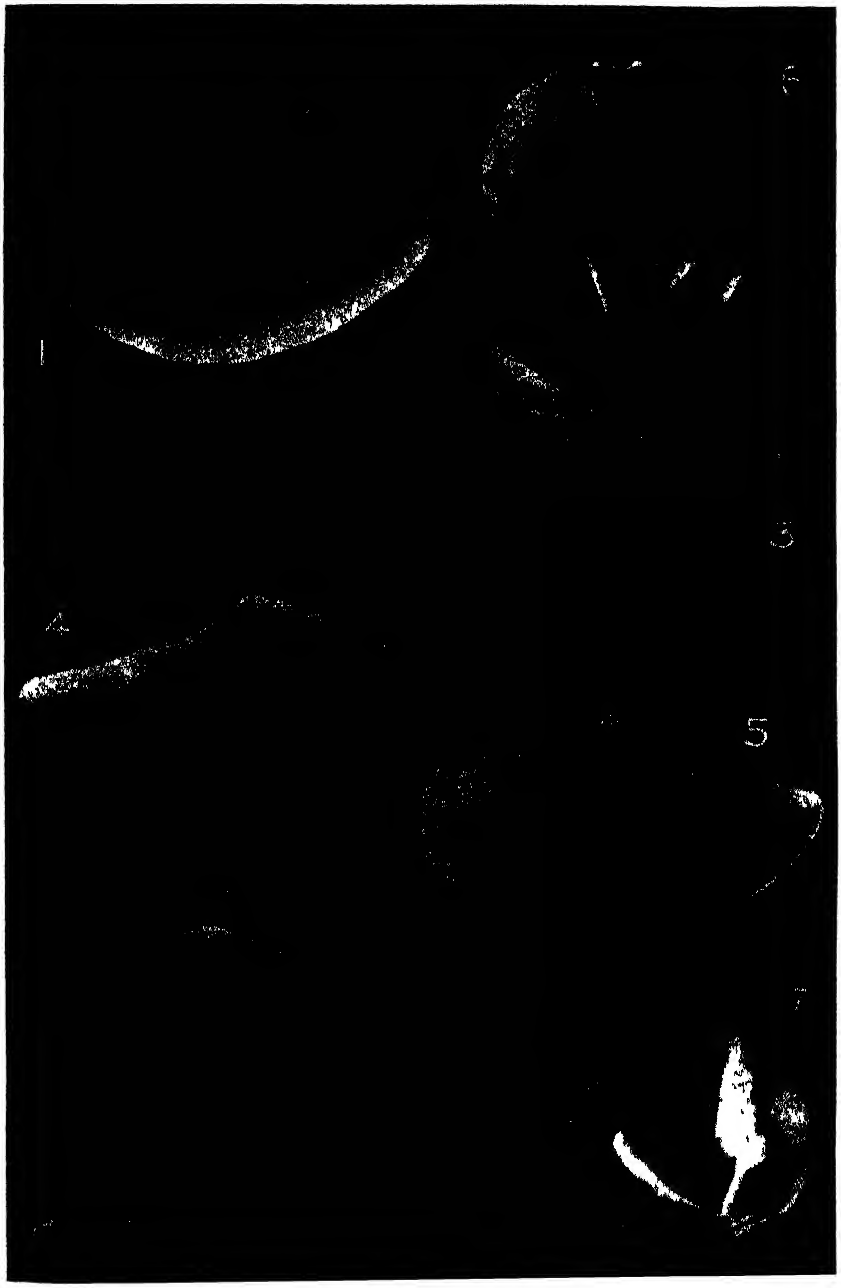
Sculpture: Dense, strong, rounded radial ribs, 4 per mm., flattened on top and with narrow interspaces. Concentric sculpture not detected, though axial ribs are raised into long blunt spines near beak on posterior slope.

Hinge imperfect; internal basal margin finely notched. Dimensions of holotype: Length, 9.2 mm.; height, 8.6 mm.; thickness, 3.8 mm.

List of Mollusca from Kaawa Beds.

The following list includes all those species examined by the authors. Recent species are indicated by an asterisk.

Alcithoe mackayi Marwick.
Alcithoe parva Marwick.
Alcithoe propearabicula Powell & Bartrum.
**Anomia trigonopsis* Hutton.
**Arca* (*Barbatia*) *novae-zelandiae* E. A. Smith.
Arca (*Acar*) *opuraensis* Powell & Bartrum.
Arca subvelata Suter.
Austrodrillia koruahinensis Powell & Bartrum.
**Austrodrillia laevis* (Hutton).
Austrofusus ngatuturaensis Powell & Bartrum.
Austrofusus propenodosa (Bartrum).
Austrotoma cf. *scopalveus* Finlay.
**Barnea similis* (Gray).
Baryspira exsputa Powell & Bartrum.
Baryspira cf. *hebera* (Hutton).
**Cardita aoteana* Finlay.
Cochlis cf. *haweraensis* (Marwick).
Cochlis notocenica (Finlay).
Cominella facinerosa Powell & Bartrum.
Crypta opuraensis Powell & Bartrum.
Crypta turnialis Powell & Bartrum.
Cuna cerussata Powell & Bartrum.
Cylichnina sp.
Dentalium several spp.—no revision attempted.
**Diplodonta zelandica* (Gray).
**Divaricella cumingi* (Ad. & Ang.).
Dosinia kaawaensis Marwick.
**Dosinia* (*Dosinia*) *lambata* Gould.
**Dosinia* (*Phacosoma*) *maoriana* Oliver.
**Dosinia* cf. *subrosa* (Gray).
Elachorbis cingulatus (Bartrum).
**Emarginula striatula* Q. and G.
Eumarcia kaawaensis Marwick.
**Gari lineolata* (Gray).
**Gari stangeri* (Gray).
Glycymeris kaawaensis Marwick.
**Glycymeris modesta* (Angas).
Glycymeris waipipiensis Marwick.
**Gomphina* (*Gomphinella*) *maorum* Smith.
Guraleus ngatuturaensis Powell & Bartrum.
Hipponyx sp.
Kaawatina turneri Powell & Bartrum.
Lima cf. *colorata* Hutton.
**Macoma edgari* Iredale.
**Macoma gaimardi* (Iredale).
**Macoma huttoni* (Smith).
**Macoma spenceri* (Suter).
Macoma subtriquetra Powell & Bartrum.
**Mactra discors* Gray.
**Mactra scalpellum* Reeve.
**Maoritellina urinatoria* (Suter).
Marginella hesterna Powell & Bartrum.
**Melanopsis trifasciata* Gray.
Miltha neozelanica Marsh. & Murd.
Montfortula kaawaensis (Bartrum).
**Murex zelandicus* Q. & G.
**Myodora antipodum* Smith.
Nemocardium finlayi Powell & Bartrum.
Neojanacus kaawaensis Powell & Bartrum.



Figs. 1-2.—*Macoma subtriquetra* n. sp. 7.5 mm. × 5.7 mm.
Fig. 3.—*Nuculana tenellula* n. sp.; paratype. 8.4 mm. × 4.7 mm.
Figs. 4-5.—*Nuculana tenellula;* holotype. 6.7 mm. × 4 mm.
Figs. 6-7.—"*Turbo*" *postulatus* Bartrum; neotype. 31.5 mm. × 31.8 mm.

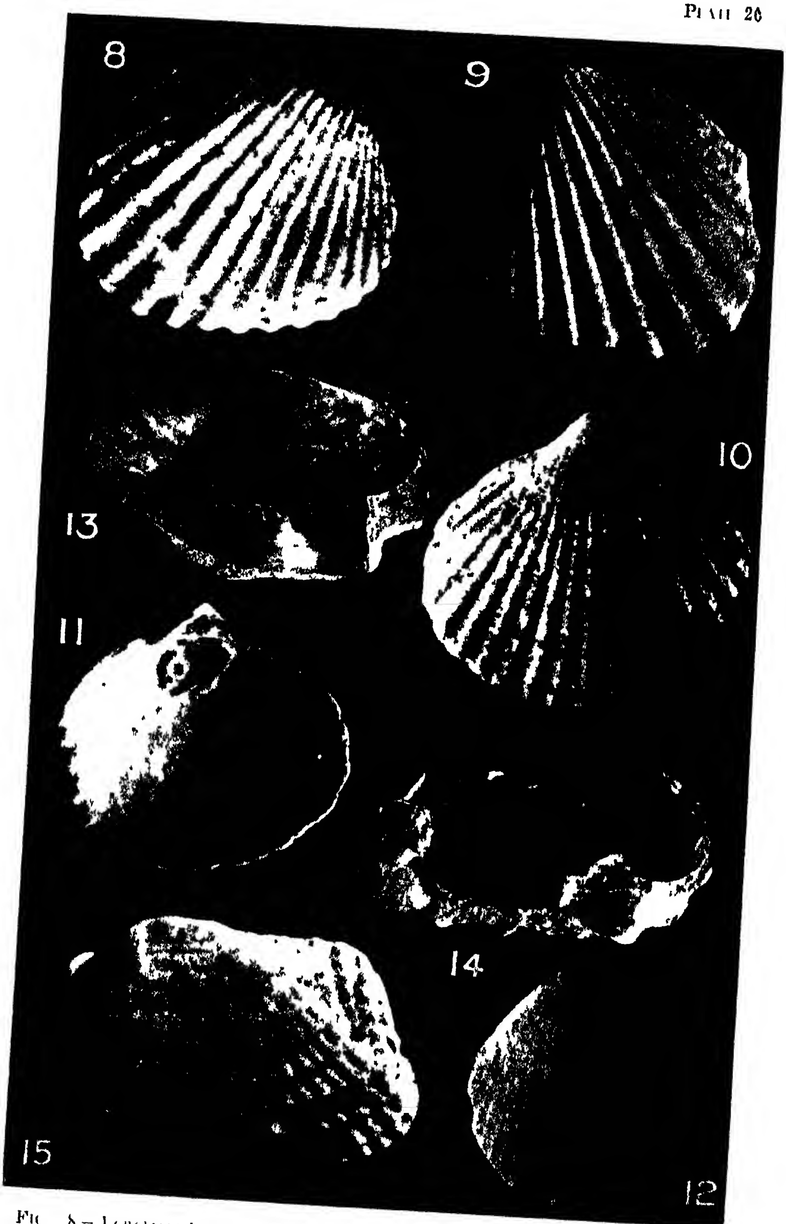
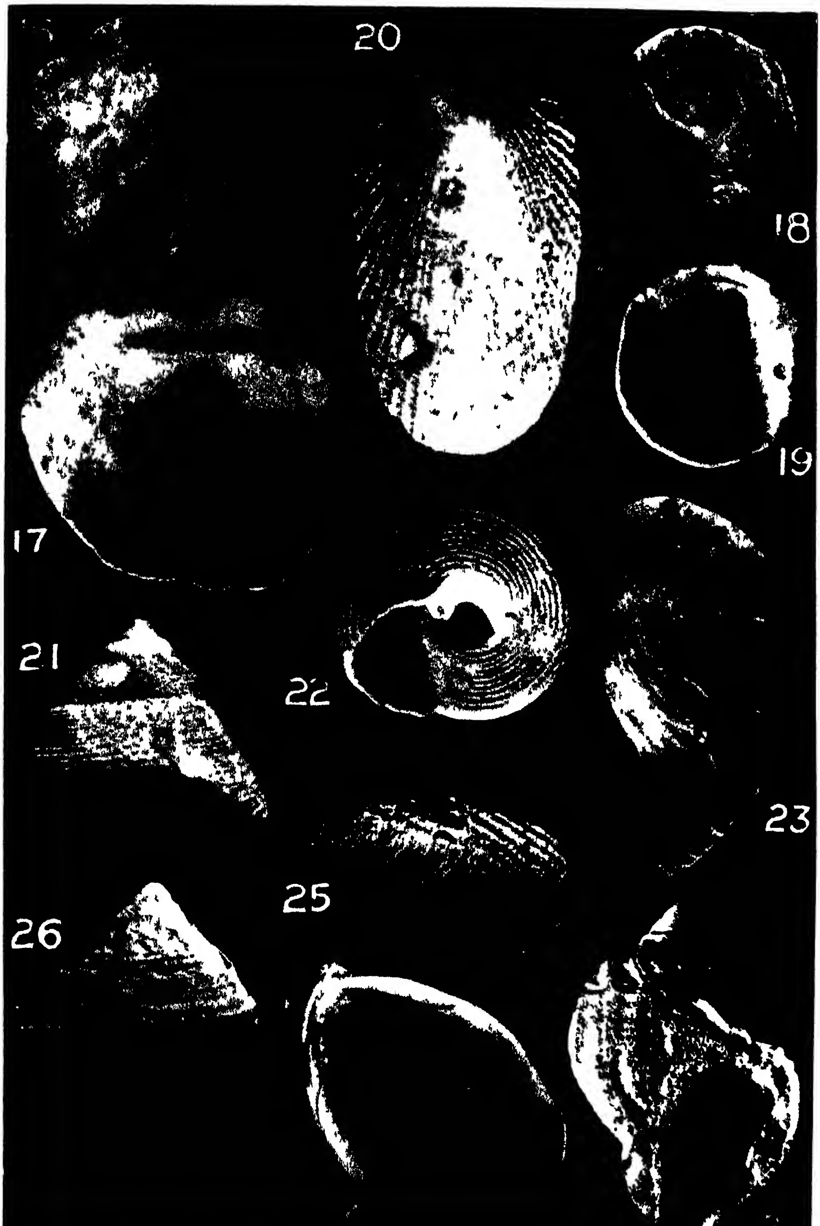
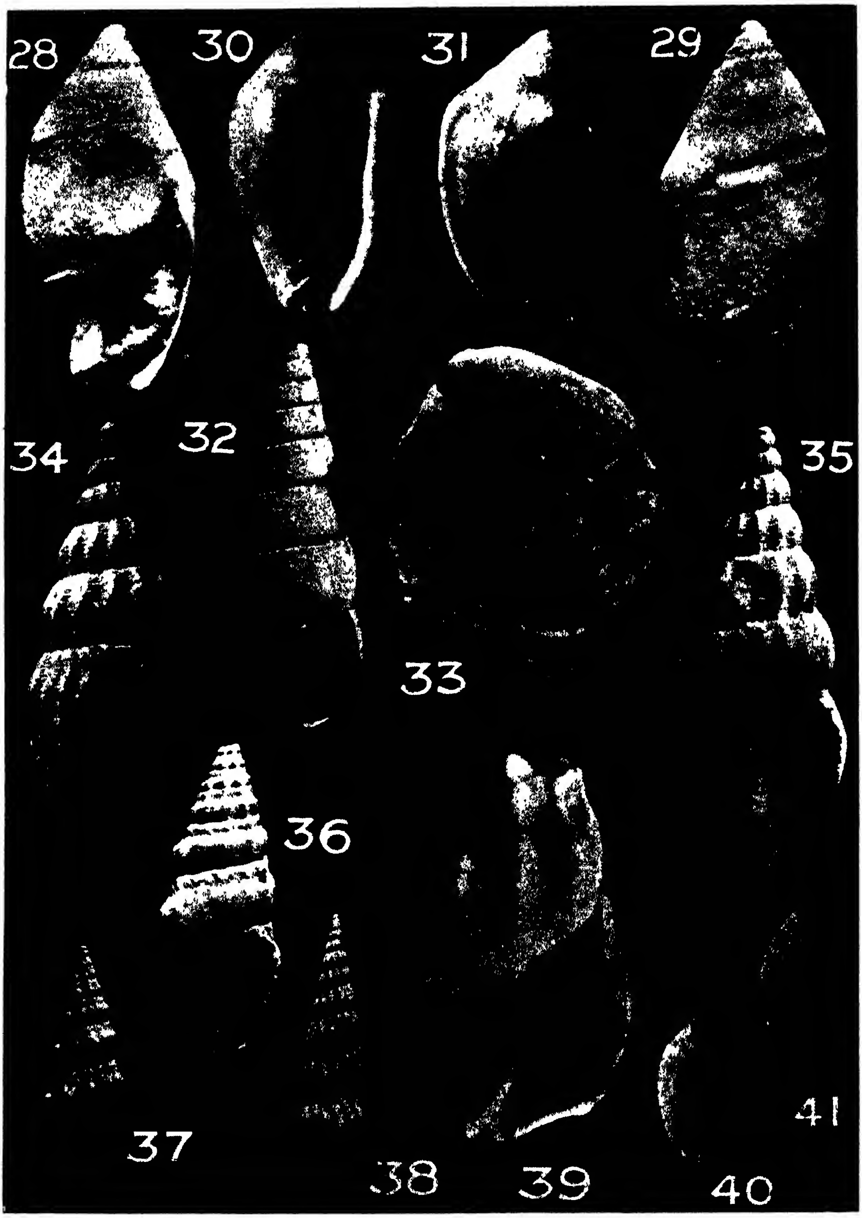


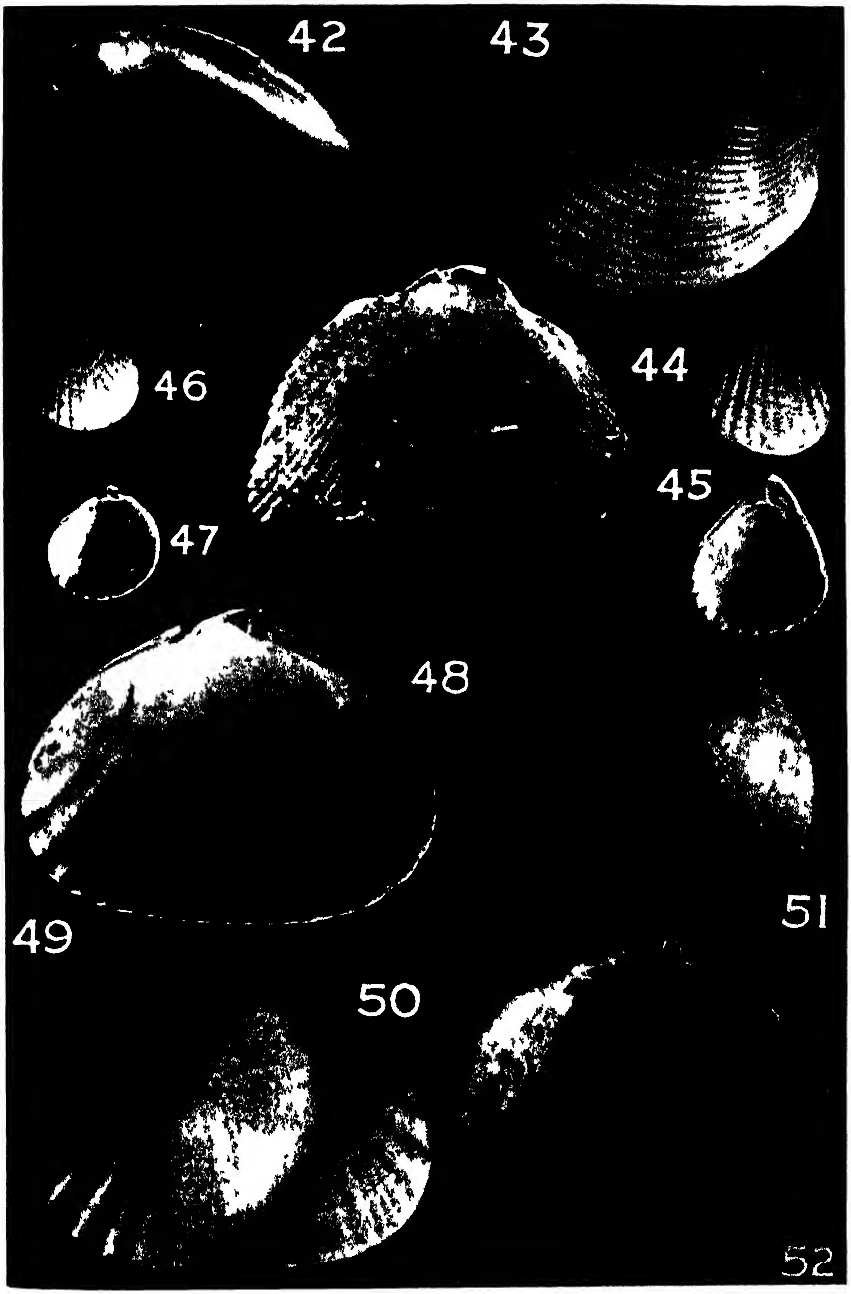
Fig. 8.—*Venericardia pene-rectangularis* n. sp., paratype. 13 mm × 10.25 mm.
Fig. 9.—*Venericardia pene-rectangularis*, holotype. 13.5 mm × 10.5 mm.
Fig. 10.—*Venericardia koruahinensis* n. sp., holotype. 6.5 mm × 5.4 mm.
Fig. 11.—*Venericardia koruahinensis*, paratype. 5.9 mm × 4.6 mm.
Fig. 12.—*Venericardia (Pleuromeris) minuscula* n. sp. 4.6 mm × 4.6 mm.
Fig. 13.—*Resania exoptata* n. sp., paratype. Height, 27 mm.
Fig. 14.—*Resania exoptata*, holotype. 26.5 mm × 11 mm.
Fig. 15.—*Arca (Acar) opuraensis* n. sp. 8.3 mm × 4.8 mm.



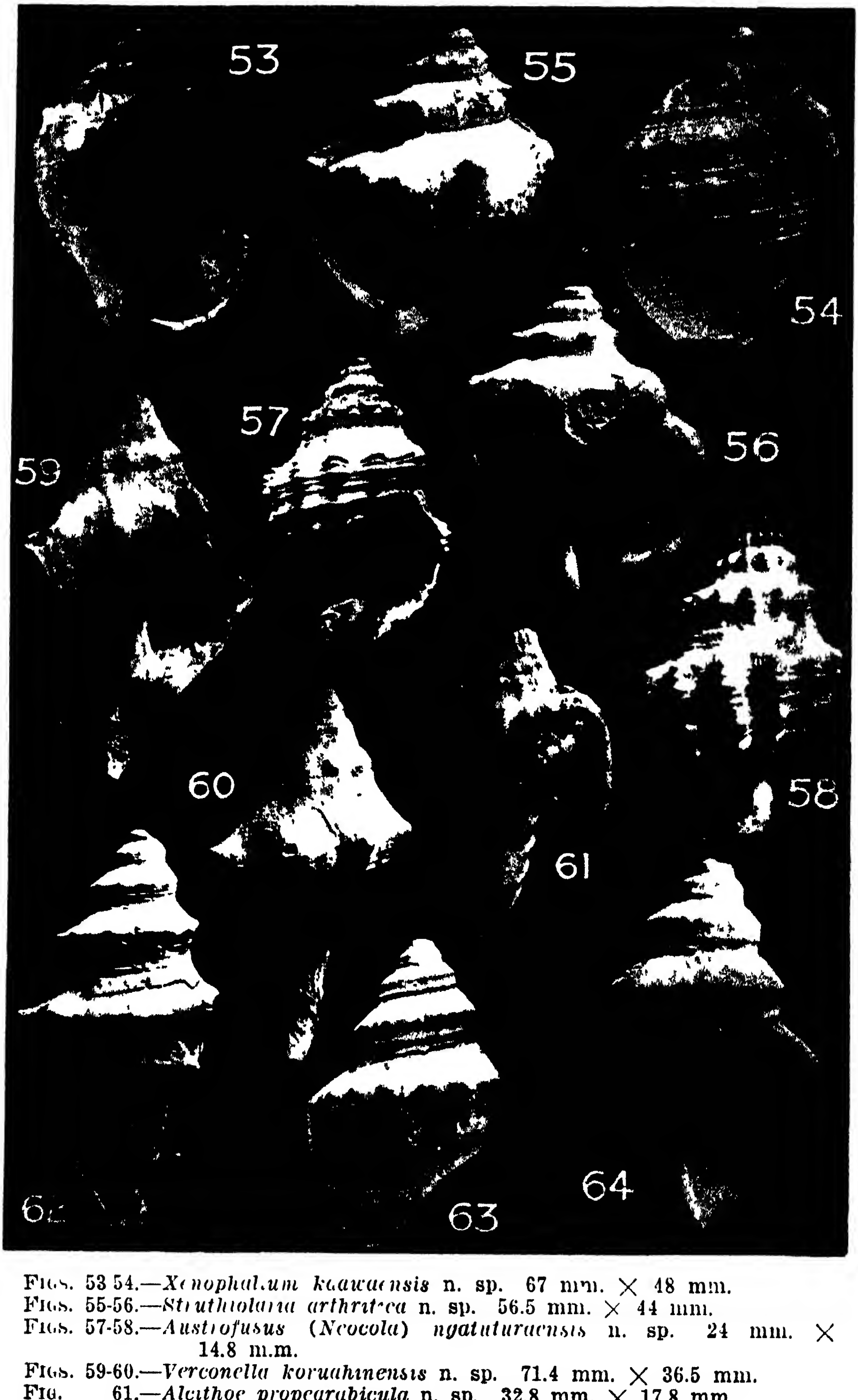
FIGS. 16-17.—*Neojanacus kaawaensis* n. sp.; holotype. 6 mm. × 6.7 mm.
FIGS. 18-19.—*Neojanacus kaawaensis*; paratype 3.2 mm. × 3.2 mm.
FIG. 20.—*Tugali opuraensis* n. sp. 11 mm. × 6 mm.
FIGS. 21-22.—*Trochus bibaphus* n. sp. 9.2 mm. × 10.7 mm.
FIGS. 23-24.—*Crypta turnialis* n. sp. 31.5 mm. × 19.25 mm. × 11.6 mm.
FIG. 25.—*Crypta opuraensis* n. sp. 25 mm. × 15 mm.
FIGS. 26-27.—*Cominella facinerosa* n. sp. 29 mm. × 20.5 mm.



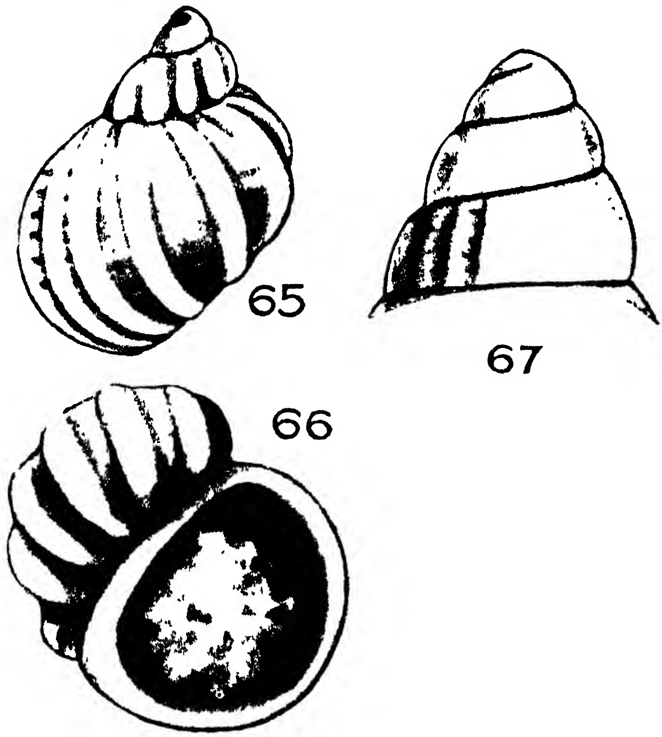
FIGS. 28-29.—*Baryspira exsputa* n. sp. 5.7 mm. × 2.8 mm.
FIGS. 30-31.—*Marginella hesterna* n. sp. 4.5 mm. × 2.8 mm.
FIG. 32.—*Odostomia* sp. 4.8 mm. × 2.3 mm.
FIG. 33.—*Hipponyx* sp. 5.4 mm. × 4.6 mm.
FIGS. 34-35.—*Guraleus ngatuturaensis* n. sp. 7.1 mm. × 2.6 mm.
FIG. 36.—*Austrodrillia koruahinensis* n. sp.; holotype. 23.7 mm. × 8.8 mm.
FIG. 37.—*Austrodrillia koruahinensis;* paratype. 18 mm. × 6.3 mm.
FIG. 38.—*Pervicacia subtilissima* n. sp.; holotype. 18 mm. × 5.4 mm.
FIG. 39.—*Pervicacia subtilissima;* broken paratype. Diam., 3.7 mm.
FIGS. 40-41.—*Rhizorus marwicki* n. sp. 2.4 mm. × 1.35 mm.



Figs. 42-43.—*Nucula ambrosia* n. sp. 5.1 mm. × 2.8 mm.
Figs. 44-45.—*Cuna carditelloides* Suter. Recent topotype. 2.5 mm × 2 mm.
Figs. 46-47.—*Cuna cerussata* n. sp. 1.7 mm. × 1.8 mm.
Fig. 48.—*Nemocardium finlayi* n. sp. 9.2 mm. × 8.6 mm.
Figs. 49-50.—*Semeloidea donaciformis* n. gen. et sp. 7.9 mm. × 6 mm.
Figs. 51-52.—*Rochefortula kaawaensis* n. sp. 6 mm × 4.7 mm.



Figs. 53-54.—*Xenophalium kaawaensis* n. sp. 67 mm. × 48 mm.
Figs. 55-56.—*Struthiolaria arthritica* n. sp. 56.5 mm. × 44 mm.
Figs. 57-58.—*Austrofusus* (*Neocola*) *ngatuturaensis* n. sp. 24 mm. × 14.8 m.m.
Figs. 59-60.—*Verconella koruahinensis* n. sp. 71.4 mm. × 36.5 mm.
Fig. 61.—*Alcithoe propcarabicula* n. sp. 32.8 mm. × 17.8 mm.
Fig. 62.—*Struthiolaria illepida* n. sp. Height, 61.5 mm.
Figs. 63-64.—*Struthiolaria pseudovermis* n. sp. 40 mm. × 25.5 mm.



FIGS. 65-66. *Kaawatina turneri* n. gen. et sp. 1.6 mm × 1.2 mm.
FIG. 67. Protoconch of *Austrofusus propenodosa* (Bartrum).

**Notomyrtea concinna* (Hutton).
Notomyrtea levifoliata (Marsh. & Murd.).
Nucula ambrosia Powell & Bartrum.
**Nucula nitidula* A. Ad.
Nuculana tenellula Powell & Bartrum.
Odostomia cf. *sherriffi* Hutton.
Odostomia sp.
Olivella neozelanica (Hutton).
Pecten williamsoni Zittel.
Pecten spp. not determined.
Pervicacia benesulcata (Bartrum).
Pervicacia subtilissima Powell & Bartrum.
**Pervicacia tristis* (Desh.).
Resania eroptata Powell & Bartrum.
Rhizorus marwicki Powell & Bartrum.
Rochefortula kaawaensis Powell & Bartrum.
Semeloidea donaciformis Powell & Bartrum.
**Spectamen* cf. *egena* (Gould).
**Spisula aequilateralis* (Desh.).
Spisula aequilateralis gilberti Bartrum.
**Spisula ordinaria* (Smith).
Struthiolaria arthritica Powell & Bartrum.
Struthiolaria illepida Powell & Bartrum.
Struthiolaria pseudovermis Powell & Bartrum.
Tawera bartrumi Marwick.
**Thyasira flexuosa* (Montagu).
Trochus bibaphus Powell & Bartrum.
Tugali kaawaensis Bartrum.
Tugali opuraensis Powell & Bartrum.
"*Turbo*" *postulatus* Bartrum.
Turris cf. *duplex* Suter.
Turritella cf. *huttoni* Cossm.
**Turritella symmetrica* Hutton.
Uber kaawaensis Marwick.
Uber propeovatus Marwick.
**Venericardia difficilis* (Desh.).
Venericardia koruahinensis Powell & Bartrum.
**Venericardia lutea* (Hutton).
Venericardia (*Pleuromeris*) *minuscula* Powell & Bartrum.
Venericardia penerectangularis Powell & Bartrum.
Vexonella koruahinensis Powell & Bartrum.
Xenophalium kaawaensis Powell & Bartrum.
Zegalerus crater Finlay.

In addition to the above, there are included also in the list of determinations by Dr. Marwick (see Henderson and Grange, *N.Z. Geol. Surv. Bull.* No. 28, 1926, p. 57) the following species:—

Acteon minutissimus Murdoch.
Alcithoe arabicula Marwick.
**Atrina zelandica* (Gray).
Cerithiopsis aequicincta Suter.
**Corbula zelandica* Q. & G.
Drillia cf. *callimorpha* Suter.
**Guraleus*† (= *Mangilia*) *sinclairi* (E. A. Smith).
**Haliotis* cf. *iris* Martyn.
**Lima suteri* Dall.
**Mytilus canaliculus* Martyn.
Odostomia georgiana Hutton.
**Ostrea angasi* Sow.
**Rhizorus*‡ (= *Volvulella*) *reflexa* (Hutton).
Turris cf. *bimarginatus* Suter.
Zaclys§ (= *Cerithiopsis*) *aequicincta* (Suter).

The shells on this supplementary list have not been examined by the authors. It is probable that *Guraleus sinclairi* of this list should be referred to the new species *ngatuturaensis*, and *Rhizorus reflexa* to the new species *marwicki*.

†See Hedley, *Rec. Aust. Mus.*, vol. 13, No. 6, 1922, p. 311.
‡See Finlay, *Trans. N.Z. Inst.*, vol. 57, 1926, p. 437.
§See Finlay, *loc. cit.*, pp. 381-2.

If consideration be given only to exact specific identifications, with the inclusion of unidentified types which are almost certainly extinct, the porportion of Recent forms in the fauna works out at 36 per cent. If all probable Recent forms be included, it is 39 per cent.

LIST OF LITERATURE.

The appended list includes the papers to which most frequent reference has been made in the text of the present paper:—

BARTRUM, J. A., 1919 a. A Fossiliferous Bed at Kawa Creek, West Coast, South of Waikato River, *Trans. N.Z. Inst.*, vol. 51, pp. 101-106.

——— 1919 b. New Fossil Mollusca, *Ibid.*, pp. 96-100.

FINLAY, H. J., 1926 a. New Shells from New Zealand Tertiary Beds: Part 2, *Trans. N.Z. Inst.*, vol. 56, pp. 227-258.

——— 1926 b. A Further Commentary on New Zealand Molluscan Systematics, *Trans. N.Z. Inst.*, vol. 57, pp. 320-485.

HEDLEY, C. 1917. Studies on Australian Mollusca, pt. 13, *Proc. Linn Soc N.S.W.*, vol. 41, pt. 4, pp. 680-719.

——— 1918. A Check List of the Marine Fauna of New South Wales, Pt. 1. – Mollusca, *Supplt. to Journ. Roy. Soc. N.S.W.*, vol. 51, pp. M 1-120.

——— 1922. A Revision of the Australian *Turridae*, *Rec. Austr. Mus.*, vol. 13, No. 6, pp. 213-359.

——— 1924. Some Naticoids from Queensland, *Rec Austr. Mus*, vol. 14, No. 3, pp. 154-161.

HENDERSON, J., and GRANGE, L. I., 1926. The Geology of the Huntly-Kawhia Subdivision, *N.Z. Geol. Surv. Bull.* No. 28 (n. s.).

IREDALE, T., 1915. A Commentary on Suter's *Manual of the New Zealand Mollusca*, *Trans. N.Z Inst.*, vol 47, pp. 417-497.

——— 1924. Results of Roy Bell's Molluscan Collections, *Proc. Linn. Soc. N.S.W.*, vol. 49, pt. 3, pp. 179-278.

——— 1927. A Review of the Australian Helmet Shells, *Rec. Austr Mus.*, vol. 15, No. 5, pp. 351-354.

MARSHALL, P., and MURDOCH, R., 1920. Some Tertiary Mollusca, with descriptions of New Species, *Trans. N.Z. Inst.*, vol. 52, pp. 128-136.

MARWICK, J., 1923. The Genus *Glycymeris* in the Tertiary of New Zealand, *Trans. N.Z. Inst.*, vol. 54, pp. 63-80.

——— 1924 a. The *Struthiolariidae*, *Trans N.Z Inst*, vol. 55, pp. 161-190

——— 1924 b. The Tertiary and Recent *Naticidae* and *Naricidae* of New Zealand, *Ibid.*. pp. 545-579.

——— 1924 c. *Zealeda* and *Bartrellina*, new fossil Molluscan Genera from New Zealand, *Proc. Mal. Soc. (London)*, vol. 16, pt. 1, pp. 25-26.

——— 1926 a. Molluscan Fauna of the Waiarekan Stage of the Oamaru Series. *Trans. N.Z. Inst.*, vol. 56, pp 307-316.

——— 1926. New Tertiary Mollusca from North Taranaki, *Ibid.*, pp 317-331.

——— 1927. The *Veneridae* of New Zealand, *Trans. N.Z. Inst.*, vol. 57, pp. 567-635.

OLIVER, W. R. B., 1923. Notes on New Zealand Pelecypods, *Proc. Mal Soc. (London)*, vol. 15, pt. 4, pp. 179-188.

POWELL, A. W. B., 1924. Notes on New Zealand Mollusca, *N.Z Journ. Sc. & Techn.*, vol. 6, pp. 282-6.

——— 1926. Mollusca from 100 Fathoms off Lyttelton, with Descriptions of Four New Species, and also a New Pliocene Fossil. *Rec. Cant. Mus.*, vol. 3, pt. 1, pp. 43-50.

SUTER, H., 1913. *Manual of the New Zealand Mollusca*, Wellington.

——— 1915. Revision of the Tertiary Mollusca of New Zealand, Part II., *N.Z Geol. Surv. Pal. Bull.* No. 3.

Two New Species of Tertiary Chitonidae.

By C. E. R. BUCKNILL, L.M.S.S.A., Lond.

[*Read before the Auckland Institute, 29th March, 1928; received by Editor, 5th April, 1928; issued separately, May 30th, 1928.*]

(PLATE 32.)

Family CRYPTOCONCHIDAE Iredale.
Genus CRYPTOCONCHUS Burrow.

Cryptoconchus marwicki n. sp. (fig. 1).

INTERMEDIATE valve, regularly arched from side to side, and in a lesser degree from before backwards. The *central or dorsal area* is a narrow longitudinal strip, rather wider at its rounded anterior end (where it projects slightly into the anterior sinus), than at its posterior end. It is sculptured with growth-lines only. The *pleural areas* which commence in front at about the level of the junction of the anterior and middle thirds of the central area, are sculptured with more or less ovoid flattened and faintly excavated granules which are arranged in the form of elongated triangles, each with a single granule at the apex and a row of six at the base. The remainder of the plate constitutes the *articulamentum* which is everywhere radially rugosely striated. It is divided on either side into a large anterior lobe and a smaller posterior lobe, the two portions being separated by a strongly marked recurved rib, beginning at the mucro and extending outwards to the incisura or marginal notch on either side; this rib presents a well marked groove along the outer half of its course. The *posterior sinus* is broad and straight. *Valve-callus* strong on the ventral surface, with a decided groove corresponding to the external rib and terminating in the solitary slit at the margin.

This specimen is the seventh plate, as compared with *Cryptoconchus porosus* Burrow, but differs from that species in having the jugal area broader in front, instead of being drawn out into a fine point; also in the more elaborate sculpture of the pleural areas.

Holotype in the Geological Survey Collection, Wellington; from the Upper Pliocene, Castlecliff, Wanganui.

I have named this species in honour of Dr. J. Marwick, to whom I am much indebted for his kindness in lending these specimens to me.

Family PLAXIPHORIDAE Iredale.
Genus GUILDINGIA Pilsbry.

Guildingia tutamoensis n. sp. (fig. 2).

Intermediate valve, almost smooth, slightly polished, and broadly rounded. **Jugal tract** faintly and roundly carinated, and lateral areas demarcated by an ill-defined diagonal line. The whole surface

is minutely stippled, and there are two narrow parallel concentric bands of a deeper colour following the anterior and lateral contour of the plate. These are quite distinct from growth-lines, and while faintly depressed on the pleural areas, are deeply impressed on the lateral areas.

The articulamentum being altogether missing in this specimen, there are neither slits nor sinus to aid in a more decisive classification.

Holotype in the Geological Survey Collection, Wellington.

"From Muddy Creek, Tutamoe Survey District, Waipu subdivision. Just above sandstone beds at junction of large southern tributary. (Mr. M. Ongley). The beds belong to the Ihungia Series of Lower Miocene or Upper Oligocene Age" (J. Marwick).

Remarks.—The valve of *Guildingia tutamoensis* is so closely similar to those of the whole shell figured in Tryon's Manual of Conchology Vol. 14, Pl. 68, fig. 5 as the type of *Plaxiphora biramosa* Q. and G., that I mentioned the fact to Mr. Tom Iredale, who I knew had examined the holotype in the Paris Museum. In reply he states: "It shows the *caelata* sculpture as you describe, but it was worn and covered with corallines when alive and the scraping had minimised the sculpture, the artist neglected to show any."

FIG. 1—*Cryptoconchus maraeuki* n sp
Holotype, 12 mm × 9 75 mm

FIG. 2—*Guildingia tutamoensis* n sp
Holotype, 6 mm × 3 mm

Chemical Fogs.

By H. O. ASKEW.

[*Read before the Philosophical Institute of Canterbury, 2nd November, 1927; received by Editor, 9th December, 1927; issued separately, May 30th, 1928.*]

PART 1.

FORMATION.

IT has been known for many years that during both chemical and physical processes mists or clouds were often formed. The clouds produced by physical means have been especially well studied in connection with condensation of water vapour on ions, from radium, or produced by thermal and electrical means; in this summary it is not proposed to discuss these clouds except so far as may be necessary from the point of view of their stability and the sizes of the particles of which they are composed. But the methods of production and the properties of clouds and mists produced during chemical processes will be considered in some detail.

The first chemical fogs to be examined appear to be those formed by the action of ozone on various reducing agents. Coulier in 1876 (3) found that ozone was very active and that this activity could not be removed by filtration through cotton wool Meissner (17) in 1863 had already found that the quantity of fog produced depended to a large extent on the choice of the reducing agent, e.g., solutions of potassium iodide or of sulphurous acid gave fogs whereas solutions of arsenites or of mercurous nitrate gave none, and an explanation of this behaviour was sought on the basis of the reactions of the hypothetical antozone. It is not necessary to go into this discussion; it is sufficient to state that the experiments of von Babo (2), Engler (10) and others, showed that the fog producing agent existed in the gas only after passage through the reducing solution. Von Babo said that this agent was hydrogen peroxide, but Engler showed that this was not always the case, since the dissolved materials in the fog-particles depended upon the reducing agent employed, with potassium iodideiodic acid, and with sulphurous acid sulphuric acid were formed. The reactions of ozone have been studied many times since, e.g. by Helmholtz and Richarz (14, 15), Townsend (28), and Rothmund (26, 27). All the work has shown that ozone will not give a fog with water alone, but that a volatile substance which may be oxidized to a stable non-volatile compound must be present. This explains Rothmund's observation that merely passing the ozone over the surface of the liquid causes fog formation. The gas carries off some of the volatile material which is then oxidized in the gaseous state, the substance then formed condenses with the water vapour present to form the discrete particles of the fog. Rothmund found that the radius of the particles of the fog was practically independent of the reducing agent.

It may be noted that the blue cloud (6) which appears round an electrical machine has been shown to be due probably to hydrogen peroxide and not to oxides of nitrogen, although the latter may also be present (19). In certain circumstances, however, oxides of nitrogen can cause condensation with the resultant formation of a cloud.

The dense clouds formed when hydrogen chloride and ammonia interact have been studied a great deal also. In this case practically all the work has been concerned with the sizes of the particles or their electrical charges. Here we have the possibility of two kinds of fog, "dry" and "moist" according as the gases are dry or saturated with water vapour, before the reaction; they may also be acid or alkaline according as excess of acid or alkaline vapour is used. It is to be expected that there will be a difference in the properties of the particles according to the type of fog obtained, and this expectation is borne out as far as "dry and "moist" neutral particles are concerned, especially in regard to ease of absorption in liquids and to the sizes of the particles; the "dry" fogs being absorbed better in salt solutions than the "moist" ones although with pure water the opposite is the case (23, 24, 25). For acid and alkaline fogs very little data are available. It is very unfortunate also that in all the investigations known to the present author in which these fogs or clouds have been examined, no analyses have been made.

Volatile organic bases "fume" strongly with hydrogen chloride vapour, e.g. pyridine, picoline, etc.; all give intense clouds when they or their solutions are brought near the acid vapour (29).

With sulphur trioxide there is also the possibility of two types of particle, "dry" or "moist." In this case the "moist" fog will really be a concentrated solution of sulphuric acid. The "dry" are well known technically and the problem of absorbing them completely is very important. Similarly the "moist" fogs are important being often troublesome in sulphuric acid concentration plants (13, 30). Sulphur trioxide in the vapour state on being passed through water condenses to form a dense fog (7). The problem of the stability and absorption of these fogs will be considered later. The same remark as was made for ammonium chloride has to be made concerning these fogs; no case has been found in the literature in which particle size and concentration of acid in the particles have been given together, and only one case has been found in which the composition and temperature of the vapour were given with the concentration of acid in the particles (see 13, 21, 23, 24, 25, 30).

Hydrochloric acid and nitric acid mists are also known technically. The former is particularly important because of the use of easily hydrolysable chlorides for cloud formation in chemical warfare (12). Many of the best cloud-producing agents consist of such a chloride base. These acid "fumes" are well known in laboratory work also, and in some cases have caused slight difficulties in atomic weight determinations. Many determinations have been made of the particle size and electrical charge of these fogs, but again no analyses are available. When the "fumes" from concentrated

hydrochloric acid are examined it is found that the radius of the particles is about 5×10^{-5} cm. (20), i.e., practically the same as that found by Rothmund (l.c.) for his ozone fogs. But the formula which Rothmund uses cannot apply to these fogs as the particles must consist of concentrated acid. Even with the comparatively dilute solutions of acid in the fog particles obtained in experiments of the present author, this formula does not appear to be of any use, and here the particles are much larger, namely, 2×10^{-4} cm. radius. Hydrobromic acid behaves in a similar but somewhat more intensified manner to hydrochloric. Its solutions "fume" more strongly; the bromides of weak bases are also easily hydrolyzed with production of a fog (5).

It is well known that the amount of "fuming" is dependent on the water vapour partial pressure of the gas in contact with the acid or the chlorides (18). An attempt has been made to get quantitative data on this point, but, although the quantity of weighable "fume" appeared to increase as the percentage humidity increased (the temperature and partial pressure of the hydrogen chloride being constant), the results were not sufficiently definite to warrant their being included here.

There are numerous references in the literature to the production of clouds in the presence of radium or of ultra-violet light (4, 9). It is not necessary for water to be present, as the vapours of many organic liquids will also condense under these conditions either in air or other gases such as hydrogen and carbon dioxide. In these cases there is a considerable amount of evidence to show that the presence of ions is not always the controlling factor (1), indeed Curie states (9) that the fogs formed in the presence of radium A have no connection with the condensation clouds with ions. Curie found that the presence of compounds, sometimes due to the use of rubber stoppers, absorbable by water caused the fogs to be much more intense. And Jones in 1925 (16), concluded that on illumination of moist halogen-air mixtures fogs were only formed when an oxidizable impurity was present.

Townsend (28) has examined the fogs formed during electrolysis. His results are discussed in a later section of this summary in conjunction with the results of others (8) on the production of electrical charges in gases by bubbling through liquids.

It is interesting to examine the properties of atmospheric fogs in relation to the explanations which have been put forward to explain their stability in unsaturated atmospheres. Because of this stability Frankland (11) has called such fogs "dry fogs." But his explanation, namely, the presence of an oil film preventing evaporation cannot be considered correct. Neither can the lowering of vapour pressure due to dissolved materials be sufficient to allow the particles to exist in a very unsaturated atmosphere. Owing to the comparatively large diameter, $1.4\text{-}3.5 \times 10^{-3}$ cm., of these particles the curvature of the surface can have only a very small effect on the vapour pressure.

Investigations have shown that even with so-called "smoke fogs," that is, fogs which are made intense owing to smoke and acid fumes, the humidity of the air may be anything from 76 to 100 per

cent., although when the fogs are dense the humidity is nearer the lower figure given (34). "Smoke fogs" generally exist in an atmosphere less saturated than white "radiation" fogs. A short calculation will show that the amount of dissolved material in the fog particles is much too small to bring about a reduction in vapour pressure sufficient to keep the particles in equilibrium with the unsaturated vapour. Assuming that a fog contains 3.3 g. of water per cubic metre (35), and that the maximum amount of sulphur trioxide is 10.6 mg. per cubic metre (33), it follows that the concentration of acid in the particles is only 0.4 per cent., which is too small to have any appreciable effect on the vapour pressure of the droplet.

It would appear that much more work is required to be done before the stability of these fogs can be satisfactorily explained.

REFERENCES.

(1) AITKEN: *Proc. Roy. Soc.*, Edin., 1916-17, *37*, 215.
(2) VON BABO: *Liebig's Ann.*, 1862-63, Bd. 2 Supp. 265.
(3) BANCROFT: *J. Phys. Chem.*, 1920, *24*, 421.
(4) BARKOW: *Ann. d. Phys.*, 1907, *23*, 317.
(5) BAXTER AND COOPER: *J. Phys. Chem.*, 1925 *29*, 1372.
(6) BIEBER: *Drude's Ann.*, 1912, *39*, 1313.
(7) BLOCH, L., *Ann. d. Chim. et d. Phys.*, 1911, *23*, 28
(8) COEHN and MOZER: *Ann. d Phys.*, 1914, *43*, 1048.
(9) CURIE: *C.R.*, 1907, *145*. 477; 1145; 1908, *147*, 379.
(10) ENGLER and WILD: *Ber.*. 1896 *29*, 1929.
(11) FRANKLAND: *Proc. Roy. Soc.*, 1879, *28*, 238.
(12) FRIES and WEST: *Chemical Warfare*, 1921.
(13) FULTON: *U.S. Bur. Mines Bull.*, 84.
(14) VON HELMHOLTZ: *Wied. Ann.*, 1886 *27*, 508.
(15) —— and RICHARZ: *Wied. Ann.*, 1890, *40*, 161.
(16) JONES: *Proc. Phys. Soc.*, 1925, *37*, 287.
(17) MEISSNER: *Jahr. d. Chem.*, 1900, 190.
(18) OSTWALD: *Grund. d. Anorg. Chem.*, 1900 190.
(19) PRINGAL: *Drude's Ann.* 1908, *26*, 727.
(20) RABEL: *Zeit. phys. Chem.*, 1920, *95*, 378.
(21) REBENSTOFF: *Phys. Zeit.*, 1905, *6*, 101.
(22) REESE: *J.S. C.I.* 1903, *22*, 354.
(23) REMY: *Zeit. Elek.*, 1922, *28*, 467.
(24) REMY ET AL: *Zeit. anorg. Chem.*, 1924, *138*, 167: *139*, 51; 69.
(25) REMY: *Zeit angew Chem.*, 1920, *39*, 147.
(26) ROTHMUND: *Zeit. Elek.*, 1917, *23*, 170.
(27) ——*Monats.*, 1918, *39*, 571.
(28) TOWNSEND: *P. Camb. Phil. Soc.*, 1900 *10*, 52.
(28a) —— *P. Camb. Phil. Soc.*, 1898, *9*, 244, 345.
(29) WATTS: *Dict. of Chem.*, 1877, *4*, 755.
(30) WELLS and FOGG: *U.S. Bur. Mines Bull.*, *184*, (1920).
(31) WILSON, C. T. R., *Phil. Trans.*, 1899, *192*, 403.
(32) WILSON, H. A., *Phil. Mag.*, 1898, (5), *45*, 454.
(33) COHEN and RUSTON: *Smoke, A Study of Town Air*, 1925 edn., 72.
(34) METEOR. OFFICE: *London Fogs*, 1904, 40 et seq.
(35) SHAW: *Aeronaut. Res Comm. Report*, 727, (1921).

ABSORPTION IN LIQUIDS.

The ease with which suspended matter may be removed from a gas has been known for many years to vary a great deal according to the substances in suspension. Indeed Schloesing in 1882 (12) even went so far as to say that it was easier to remove one constituent from a gas mixture than to remove suspended matter. Gibbs (7)

has also drawn attention to this point in regard to the efficiency of gas masks.

Tyndall found during his experiments on optically pure air that dust motes of certain types were extremely difficult to remove; in many cases removal was possible by prolonged contact with concentrated sulphuric acid, the explanation being that the acid removed the adsorbed gas film and probably even brought about the complete destruction of the particles (15, 16). The question of the removal of solid particles also played an important part in the development of the experimental work on the production of fogs with ozone, since some observers considered that solid nuclei must have been present when condensation occurred, and others that all solid particles had been removed by passage of the gas through washbottles, etc.

On the technical scale absorption of fumes is very important, especially in the case of acid works, smelters and gas works (10, 11, 6, 4).

It has been pointed out by Knietsch (9) that the ease of absorption of sulphur trioxide is determined to some extent by the rate of cooling of the gases. The clouds formed by rapid cooling were much more difficult to absorb than those formed by slower cooling. In the former case the particles will be smaller and will consequently have a much greater specific surface on which adsorption of air may occur. This layer of adsorbed gas is probably the chief factor in determining the ease of absorption of the particles. And in the contact process the particles are dry and very difficult to wet. Reese (10) has illustrated this by passing air carrying sulphur trioxide through two washbottles in series, the first containing dilute acid and the second concentrated; a fog not absorbed by the strong acid is formed. If the order is reversed no fog is formed; showing that the strong acid apparently destroys the adsorbed gas film and thus permits wetting of the particles to take place. Remy (11b) has found that the percentage absorption of (contact) sulphur trioxide in sulphuric acid of different concentrations runs parallel to the boiling point, a maximum being obtained in each at about 98 per cent. acid. It has also been found that moist (i.e. containing sulphuric acid) fogs are absorbed better in water than the dry fogs, probably because the protecting layer of gas in the latter case renders wetting difficult. For example Remy (11c) found that with a fog from which there was absorbed 46 per cent. when moist, only 7 per cent. was absorbed when dry. But concentrated salt solutions absorbed the dry better than the moist (11a). When these fogs are tested by other methods e.g. filtration, the results are not so simple. When passed through a filter paper 71 per cent of the moist fog was retained but only 36 per cent. of the dry. When, however, the gas was passed through gas mask carbon 22 per cent. of the moist fog and 82 per cent. of the dry fog were removed. In these cases the explanation presumably is that the particles in the moist fog are larger than those in the dry, and consequently their rates of diffusion are much lower.

Remy has also determined the amount of absorption taking place when these fumes are passed through alkaline solutions, both

in the presence of an indifferent gas (air) and of an acid gas (carbon dioxide). He finds that in 20 per cent. potash the absorption is much lower than in pure water whether the fog is dry or moist. When a 1 : 1 mixture of air and carbon dioxide is substituted for air alone a considerable increase in absorption occurs; but in this case it is necessary to remember that as the bubbles of gas bearing the particles pass through the liquid they will be continuously decreasing in size. and hence better contact with the solution will be obtained. The following table gives some of Remy's figures (11c):—

Table 1.

CHEMICAL FOGS.

SO_3 fog	Solution	Per cent. absorbed.
Moist	Water	46
"	20 per cent. KOH	32
Dry	Water	8.5
"	20 per cent. KOH	0.0
Moist (air only)	" " "	62.
" (air: CO_2, 1 : 1)	" " "	80.

In the last two experiments the fog was passed through five washbottles instead of one as in the previous cases.

Washing the air from concentration plants with dilute soda ash solution is said (2) to remove the particles of acid quite satisfactorily, although this would not be expected from Remy's work given in Table 1. (See also 8).

Ammonium chloride fogs have been examined by similar methods and, in general, similar results have been obtained, except that the dry fogs seem to be absorbed more easily than the moist, probably because of their greater mobility. Caustic potash again causes a decrease in absorption, the dry fog being absorbed more easily than the moist (11a, b, c).

In 1898 Wilson (18) carried out experiments with clouds consisting of fine particles produced by an air blast impinging on the surface of different solutions. Among the solutions which he used were H_2SO_4, KOH, NaCl, and the non-electrolytes sugar and glycerine. Not only these solutions but all in which a non-volatile compound was dissolved behaved in the manner described below. After formation the spray was passed through concentrated sulphuric acid and then through water; in the space over the acid no particles were visible, but in the space over the water the cloud reappeared, except with a distilled water spray. The explanation of this behaviour is that the water is removed from the particles by the strong acid leaving very small solid nuclei which are too small to give a visible cloud, but which on again coming into contact with water can by reason of their hygroscopic nature cause condensation to occur and hence the reappearance of the cloud. Wilson found that hydrochloric acid below 5 per cent. and acetic acid did not give the above results. The density of the clouds in the flask containing the water was apparently proportional to the molecular concentration of the dissolved material and was equal for equal con-

centrations of the different substances, although a considerable change in the concentration had to be made to produce an appreciable change in the density of the fog. After electrification this re-appearance of the cloud could not be obtained, although the electrification was not removed. This would show that the charge remains on the nucleus after evaporation of the moisture, as is to be expected from the results of Gallrotti (quoted in 5), and owing to the slow diffusion of the nucleus the charge is not lost.

The above experiments show why ozone fogs behave as did Wilson's sprays after drying and subsequent contact with water vapour (28).

Now although the above experiments have shown that absorption by bubbling is very incomplete, no information is given as to what effect passage through liquids has on the composition of the particles. The change in particle size has been investigated (11b) for the above mentioned fogs and is considered in a later section of this summary. Some experiments by the present author have shown that even by passing a fog through one washbottle a very considerable change in the concentration of the dissolved material may be effected. A 50 per cent. (by vol.) alcoholic soda solution (1.24 N) was employed for generating a fog with hydrochloric acid. When the resulting fog was passed through a washbottle, according to the rate of passage of the gas, the absorption of the fog varied between 72 and 44 per cent., the higher figure being obtained with a narrower jet and a slightly lower rate than the lower. The most noticeable effect was, however, the reduction in the acid concentration of the fog particles. This was reduced, according to the conditions of the experiments, from 5.1 and 4.5 per cent. to 2.0 and 1.6 per cent. respectively. Since only about half of the particles were retained by the solution, the above reduction of acid must have been caused by condensation of vapour on to the particles with consequent increase in size. No definite experiments are however available to show whether it is so, but Remy's experiments would indicate this; nor were analyses made of these fogs to see if this condensation was preferential i.e., whether alcohol or water was the more easily condensed. It is hoped that this question will be examined more fully at a later date.

Allied to this question of absorption is that of methods of filtration of clouds and smokes. Owing to the very small particles filtration presents many difficulties. The best methods for the removal of very small particles appear to be thermal filtration (3) and electrical precipitation. Tolman has found that even the small particles of tobacco smoke are readily removed. In a temperature gradient the particles always move towards the cold end (1); consequently in Tolman's experiments the smoke particles were deposited on the cold tube of the filter. Electrical precipitation is not considered further in this paper.

In chemical warfare the removal of the particles of smoke and gas screens from the air before being breathed is very important. It has been found that there is a minimum efficiency for a filter at a certain size of particle, i.e., the filtration is more perfect with particles smaller or larger than this critical size (7).

Tolman has put forward a theory which explains such a result (13). As the particles pass through the filter they will be subjected to many changes of direction and hence will in many cases be violently thrown against the walls of the small pockets in the filter material. Some of the particles, especially if very small, will diffuse to the walls and be retained; but some larger ones will not readily diffuse to the walls and yet will not be vigorously thrown to the walls by the centrifugal force. Large particles will be removed by centrifugal action. Hence the theory requires, as is found in practice, that the efficiency of a filter should pass through a minimum as the radii of the particles vary.

For a given material the efficiency of a filter varies with the density of packing. If long fibres are loosely packed a much more efficient filter is obtained than if short fibres are tightly packed. In accordance with this fact, the present author has used "woolly asbestos" loosely packed for the filtration of fog particles for estimation and analysis.

Remy (11c) has filtered sulphur trioxide (or sulphuric acid) and ammonium chloride fogs, both in the dry and moist state, through various materials. The great differences between gas mask carbon and, say, filter paper is brought out. For the dry fogs, and thus with smaller particles, with ammonium chloride the carbon is as efficient as filter paper, while for sulphur trioxide the former is the more efficient; but for moist fogs in each case the filter paper is much the more efficient. The carbon owes its efficiency largely to the diffusion of the particles, and diffusion is much more rapid with the dry particles; the filter paper is more efficient for moist fogs because of the larger sizes of the particles in such cases.

In connection with Remy's experiments on the filtration of sulphur trioxide, it is interesting to note that Weber (17) has used ordinary filter papers for removing the particles of sulphur trioxide (sulphuric acid) from a gas stream in quantitative experiments on the amount of acid carried off in technical gases.

REFERENCES.

(1) Aitken: *Trans. Roy. Soc., Edin.*, 1884, *32*, 239.
(2) *Alkali Inspect. Rep.*, 1924, 7.
(3) Bancroft: *J. Phys. Chem.*, 1920, *24*, 421.
(4) Blake: *Gas World*, 1926, *84*, 102.
(5) Bloch: *Ann. d. Chim. et d. Phys.*, 1911, *23*, 28.
(6) Ehrenberg: *Die Bodenkolloide*, 1915, 226.
(7) Gibbs: *J.S.C.I.*, 1926, *45*, 180.
(8) Gille: *Zeit. angew. Chem.*, 1926, *39*, 401.
(9) Knietsch: *Ber.*, 1901, *34*, 4081.
(10) Reese: *J.S.C.I.*, 1903, *22*, 354.
(11) Remy: (a) *Zeit. Elekchem.*, 1922, *28*, 467.
(b) *Zeit. anorg. Chem.*, 1924, *138*, 167; *139*, 51, 69.
(c) *Zeit. angew. Chem.*, 1926, *39*, 147.
(12) Schloesing: *C.R.*, 1882, *94*, 1187.
(13) Tolman et al: *J.A.C.S.*, 1919, *41*, 299.
(14) Townsend: *P. Camb. Phil. Soc.*, 1900, *10*, 52.
(15) Tyndall: *Phil. Trans.*, 1870, *160*, 337.
(16) ib: *Proc. Roc. Inst.*, 1870, *6*, 3.
(17) Weber: *J.I.E.C.*, 1924, *16*, 1239.
(18) Wilson, H. A., *Phil Mag.*, 1898, (5), *45*, 454.

PART 2: EXPERIMENTS.

ACID CHLORIDES.

The experiments described in this paper have been carried out in order to find the cause of the production of a fog when a gas stream carrying phosgene, after previous passage over charcoal, active or inactive, was bubbled through a solution of alcoholic soda. This fog occurred only when the charcoal had adsorbed so large a quantity of phosgene that measurable amounts passed through with the air.*

Numerous experiments have shown that this fog is not due to phosgene itself but to hydrochloric acid formed by the hydrolysis of the former by moisture in the charcoal. Although essentially the same method of testing charcoal for the adsorption of phosgene has been used by others (Fieldner *et al. J.I.E.C,* 1919 *11,* 519), no previous record of the production of these fogs is known to the present author.

Parallel experiments with phosphorus oxychloride and hydrogen chloride have also been carried out, all of which led to the conclusion that the fog was produced only when free hydrogen chloride occurred in the gas, and, moreover, only when free alkali was present: whenever the solution was free from alkali, when using phosgene, only a very thin fog or none at all was obtained, and when using hydrogen chloride no fog was ever obtained. Alcohol was not necessary as fogs were formed with aqueous solutions, but when a liquid such as alcohol, acetone, or ether was present also, the fogs produced were much more dense.

The concentration of the hydrochloric acid in the fog particles was relatively large, and was, moreover, remarkably constant for a given solution, even when the rate of bubbling and size of jet employed varied between somewhat wide limits. In 50 per cent. (by vol.) alcoholic solution this concentration was 5 per cent., in aqueous solutions it was somewhat higher, namely, 8-10 per cent.

By experimenting with different sized jets it has been found that in general in aqueous solutions the fogs are denser the greater the radius of the jet, but in the alcoholic solution the opposite is the case; increase in the rate of passage of the gas always increased the amount of fog.

Experiments in which the fog formed in one solution vessel was carried by the gas stream into a second have shown that the radius of the jet in the second vessel was important in governing the amount of fog absorbed. Quantitative experiments have shown that not only was the amount of fog in the second vessel altered, but also that the concentration of the acid in the particles changed considerably.

EXPERIMENTAL.

The *Phosgene* was purified by the methods of Reeves (*J.S.C.I.*, 1924, *43*, 279T), namely, either by passing the gas through very dilute potassium iodide solution or by shaking with mercury, while in some cases a combination of both methods was used. The gas was then dried by passage through a column of calcium chloride and

*This phenomenon was noticed during the War by Prof. J. C. Philip, but was not further examined at that time.

stored over mercury: the pure dry phosgene did not attack the mercury. The head of a gas burette was fitted with a three-way tap, one branch of which was connected with the system of flasks. This outlet tube had a further three-way tap by means of which the gas could be passed either through the charcoal tower and through a mixing tube or direct to this tube and thence to the absorbing solution. Dry air was drawn through the other outlet tube of the burette and mixed with a definite quantity of phosgene vapour. This mixed gas contained one per cent. by volume of phosgene.

Phosphorus oxychloride vapour was freed from chloride and hydrogen chloride by passage over zinc dust and then dried by calcium chloride. Air carrying the vapour could pass either through the charcoal or direct to the solution.

Hydrogen chloride vapour was obtained by passing dry CO_2 free air through the concentrated acid followed by drying of the mixed gas with calcium chloride: frequent renewal of the acid was necessary owing to the rapid reduction in the partial pressure with slight decrease in concentration in the liquid.

The *charcoal* chiefly used was an active one in thin flakes, and was used in both its ordinary state of equilibrium with the atmosphere and its well-dried state. It gave, on analysis, moisture (loss at 160°C.) 13.54 per cent., ash 3.39 per cent. Before being used for the experiments the charcoal was saturated with the pure dry chloride vapour, dry air being then drawn through for a time to remove excess vapour.

The *soda solutions* were made up from sodium hydroxide "ex sodium" by dissolving a weighed amount in water and precipitating the carbonate present by a slight excess of baryta. After settling the clear liquid was decanted off. The alkaline solutions of the organic compounds used were made up by volume; for the more dilute solutions dilution was carried out with aqueous soda of the same concentration. In all cases the soda was approximately 1.25N.

The *jets* had their tips ground square and were chosen from a number for the regularity of their diameters and wall thicknesses. The internal radii were measured with a travelling microscope.

The term "depth of liquid" used later refers to the distance between the tip of the jet and the surface of the solution.

In carrying out an experiment the mixed gas was led, either after passing through a column of charcoal or direct through one (or two) washbottles containing the alkali solutions, any fog that was formed being filtered out by "woolly asbestos" placed in a stoppered U-tube which was weighed before and after an experiment. This arrangement was found to form a very efficient filter (for the practice and a theory of filters for fogs see Tolman *et al.* (*J. Am. Chem. Soc.*, 1919, *41* 299). After a given volume of gas had been drawn through, the apparatus was flushed out with air. Blockage of the tips of the jets by sodium chloride sometimes occurred, particularly when the stronger alcoholic solutions were used.

In a number of cases the chloride in the absorption flasks was estimated whence the original partial pressure of the hydrogen chloride (when this was used) could be calculated. The asbestos

holding the fog was removed and it and the tube washed out with distilled water the acidity and the total chloride being then estimated with alkali and silver nitrate respectively. No estimations have been made of the quantities of the organic compounds which condensed from the vapour during the formation of the fogs.

Since asbestos adsorbs considerable quantities of water and alcohol (ether etc.) vapours air from a solution of the same composition as that in use for a given set of experiments was drawn through the asbestos tubes until equilibrium was established. The importance of this precaution is shown by the following figures: solution used, 1.24N Na OH in 50 per cent. (by vol.) ethyl alcohol, the weight of vapour adsorbed by one gram of asbestos was 12.1 mg. at 24°C.

QUALITATIVE EXPERIMENTS.

Undried Charcoal: On passing a one per cent. phosgene-air mixture through the column of charcoal and then through the alkali solution a fog was formed, the density being dependent on the time of contact of the phosgene with the charcoal, and also on the composition of the liquid. Solutions containing ethyl alcohol, amyl-alcohol, acetone, formaldehyde and ether gave intense fogs especially when considerable amounts of these compounds were present. Glycerine gave only thin fogs of about the same density as those from the simple aqueous solution. With the former liquids a large range of densities was obtained from very white fogs opaque in a thickness of a few millimetres down to those aparently not more dense than the fogs from the simple solution.

In all cases, except in the simple aqueous solution, no free phosgene was found in the air after the particles were filtered out, provided that alkali was present. This is rather remarkable in view of the difficulty of obtaining complete absorption even in concentrated aqueous solutions (Reeves, l.c.). Only a trace of alkali was necessary for fog formation to begin with any of the solutions.

It was noticed in all cases when fogs were formed that the gas in the mixing tube had a sharp smell quite different from that of pure phosgene; indeed, it was that of hydrogen chloride. In order to remove any free acid which might be present in the gas, some small glass tubes were loosely filled with chloride-free zinc dust. As an extra precaution that no hydrogen chloride should enter the charcoal one of these "zinc tubes" was placed immediately before it. It was found that during an experiment the tube in front of the charcoal remained cool and dry, while a similar tube placed after the charcoal became warm and the zinc dust moist and sticky. On washing out the zinc with water and testing for chloride, the former tube gave only a small precipitate (due to adsorbed phosgene) while the latter gave a copious precipitate.

When the second zinc tube was in use no fog was ever obtained; by rapidly changing the tubes while the same gas mixture was passing it was shown that the presence or absence of the first zinc tube had no effect on the formation of fog only the second being of importance.

These results led to the conclusion that free hydrogen chloride in the gas was the cause of the fogs; this chloride could come only from the phosgene by hydrolysis during its contact with the charcoal.

Phosphorus oxychloride vapour gave similar results to phosgene.

When hydrogen chloride was used, the first zinc tube always became hot and the second remained cool. In this case no fog was ever obtained. But if the first were omitted, then the second became hot, but no fog appeared. It was only when both tubes were omitted that any fog was obtained. The conclusion was that free hydrogen chloride was the cause of the fogs.

Dry Charcoal: Two separate lots of the same sample of charcoal as was used in the experiments described above were dried in an air oven by constant weight. The whole apparatus was then carefully dried.

In all experiments using phosgene or phosphorus oxychloride all the zinc tubes remained cool and dry and no fogs were formed; also these gases appeared in quantity in the mixing tube after passing through the charcoal, there being now no trace of hydrogen chloride.

When hydrogen chloride was employed, copious fogs were formed whenever the zinc tubes were omitted.

These experiments confirmed the conclusion drawn from the previous experiments.

No Charcoal Used: Phosgene vapour, either pure or mixed with air was passed through the liquid either with or without alkali. In the absence of alkali, absorption was incomplete, but no fog appeared in the first washbottle, although in a few cases a very thin fog was formed in the second. In the alkaline solutions except simple aqueous, absorption was complete and no fogs were formed.

Phosphorus oxychloride under similar conditions also gave no fog.

Hydrogen chloride, in all cases where alkali was present, gave fogs. The dense fogs readily passed through the second washbottle, the reduction in density being the greater the narrower the jet. Thin fogs were often almost completely absorbed in the second flask. A layer of benzol on the surface of the alkali solution had no apparent effect on the density of the fog.

In all the experiments described above, it was shown by using a number of glass wool and asbestos filtering plugs in different parts of the apparatus that dust particles were not acting as nuclei on which condensation could take place, since these plugs had no effect on the quantity of fog obtained.

QUANTITATIVE EXPERIMENTS.

Fog from the phosgene-air mixture was collected after having passed through the second wash-bottle (alcoholic soda being used as absorbing solution), and on analysis gave: weight of fog per litre of air, 5.8 mg.; hydrogen chloride in the particles, 1.46 per cent. It will be seen later that the composition of this fog is, within experimental error, the same as that obtained under similar conditions with hydrogen chloride.

With hydrogen chloride a number of experiments with both alcoholic and simple aqueous solutions have been carried out.

In Table 1 are given some results obtained with a strong alcoholic solution. It will be observed that the concentration of acid in the

particles remains almost constant. Approximately 3.2 per cent. of the total chloride carried by the gas stream appeared as fog. All weights of fog are given in mg. per litre of air.

When the fog formed in the first flask was carried through a second before the gas was filtered, not only did a reduction in density occur, but the concentration of acid in the particles was much reduced also. In the column headed "original fog" in Table 2 are given the quantities (some of which were obtained by extrapolation from other data) which are formed in the first flask under the conditions specified, and under "per centage absorption" the per centage of this fog which is absorbed by the second washbottle.

TABLE 1.

Solution: Ethyl alcohol 50 per cent. (by vol.) with NaOH 1.24N. Temp. 22—24°C.

Radius of Jet mm	Rate c c /min	Fog mg	HCl Per Cent
0.60	167	142.8	5.06
0 60	167	144 5	5 10
0 60	187	164 0	5.23
0.99	157	137.5	4 92
0.99	163	141.5	5.00
0.99	190	159 4	4.58
1.66	190	139.2	4.53

The data given show how much more effective is the narrower jet in reducing both the density of the fog and the acid concentration in the particles (compare Table 1).

TABLE 2.

Solution: NaOH 1.24N in 50 per cent (by vol.) ethyl alcohol. Temp.: 23°C.

The symbols 1 and 2 refer to the first and second washbottles respectively.

Radius of Jet mm 1	2	Rate c c /min	Original Fog mg	Fog mg	Per Centage Absorption.	HCl Per Cent.
0 60	0.90	200	172	89.2	48.6	1.99
0 60	0.99	219	187	105.1	43 9	2.00
1.66	0.60	200	145	40.8	71.8	1.59

The whole of the reduction in density can not be attributed to the influence of the jet as an unknown amount settles out on the sides of the flasks and on the walls of the tubes through which the air passes.

With aqueous solutions experiments in which the depth of liquid was varied have been carried out. The flasks in which the acid was absorbed were of such dimensions that using the same volume of soda solution in each case (in order to keep the concentration gradient constant) the different "depths" of liquid could be obtained. In some cases only a small quantity of fog was formed, so that the analyses are perhaps not very accurate, this being the reason for the high per centages of chloride given for some of the fogs.

From the results given in Tables 3 and 4 it will be seen that with a given jet in every case the quantity of chloride escaping absorption and of fog formed increased as the rate of passage of the gas increased.

TABLE 3.

Solution: 1.26N NaOH.

Depth of Liquid. 3.75 cm. Temp. 20—23°C.

Radius of Jet mm	Rate c c /min	Fog mg	HCl Per Cent
1.32	194	16.7	9.8
	190	16.8	9.5
	174	13.3	11.2
	174	13.1	10.3
	160	11.3	11.0
	148	7.2	13.2
1.08	195	19.7	9.5
	185	19.1	9.7
	170	17.2	10.6
	154	12.7	11.1
	140	8.8	14.3
0.81	200	24.9	9.9
	194	24.2	9.9
	167	19.9	9.4
	163	19.2	10.0
	150	16.2	9.7
	141	12.7	9.5
	138	12.2	9.1

The jets did not behave alike, however; for at 3.75 cm the quantity of fog and of chloride at a given rate increased as the radius of the jet decreased, while at 7.4 cm. the opposite was the case. At an intermediate depth, 5.25 cm. the quantity of fog formed at a given rate with the two narrowest jets was almost independent of the radius.

TABLE 4.

Solution: 1.26N NaOH.

Depth of Liquid: 7.4 cm. . Temp.: 21—23°C.

Radius of Jet mm.	Rate c.c./min.	Fog mg.	HCl Per Cent
1.81	195	28.3	10.7
	194	28.4	9.9
	167	24.5	10.0
	160	23.1	10.0
	148	21.7	8.0
1.32	194	27.0	9.8
	186	26.5	9.8
	178	25.0	9.3
	160	21.5	9.2
	135	18.3	9.4
1.08	200	26.8	8.9
	186	24.9	9.1
	172	23.1	9.5
	167	23.1	8.4
	151	20.8	8.7
	138	19.1	8.1
0.81	200	24.9	7.9
	182	23.4	8.5
	167	22.0	8.4
	160	21.2	7.8
	145	19.2	6.7

When the data given in the above tables were graphed, plotting mg. of fog against rate of passage of gas, it was found that at 3.75 cm. all the lines were curved, but that at 7.4 cm. there was a transition according to the radius of the jet from practically straight lines to lines with a distinct curvature. The lines for 5.25 cm. had a very decided curvature, but were intermediate in shape between those corresponding to the other depths.

It is also seen that the concentration of acid in the particles remains very steady, especially for the fogs formed at the greater depth of liquid; in this latter case the concentration is slightly lower than that for the shallower liquid.

When the aqueous solutions are used only 0.8 to 1.5 per cent. of the acid vapour originally present in the gas stream escapes absorption, but the concentration of acid in the particles is considerably higher than with the alcoholic solution.

In Part 3 the partial pressure of the water vapour in the air in contact with the fog particles will be considered.

All the experiments described above had been carried out using an "inverted jet," that is, used in the same manner as the inlet tube of an ordinary washbottle. It was desired to calculate the time of contact of the bubbles with the solution, but owing to the manner in

which the bubbles formed and left the glass tip this could not be done with the desired accuracy. Experiments made with "erect jets," and described in a later paper, have, however, made this calculation possible.

Part 3.—The Absorption of Hydrogen Chloride and Bromide in Alkaline Solutions.

It was shown above that hydrogen chloride vapour was incompletely absorbed in alkaline solutions, the unabsorbed portion condensing above the surface of the liquid to form a fog. In this paper are described experiments made using aqueous alkali solutions, and varying the factors which had previously been found to affect the quantities of fog formed.

1. In all the following experiments the jets have been used in the "erect" position. These jets were chosen from a number for their regularity of radius and wall-thickness; the internal radii of those used were 1.81, 1.32, 1.08, 0.82 mm. respectively. The volumes of the bubbles formed at the tips of the jets, and the velocities with which these bubbles rose through the liquid were also determined. In Table 1 are given the relevant data.

Table 1.

Internal Radius mm	Rise of Bubble Second x 10- Per Centimetre	Volume of Bubble c c x 10^2	(Calc.) Radius of Bubble mm
1.81	3.95	8.8	2 76
1.32	3.78	6.0	2.43
1.08	3.74	5.5	2.36
0.82	3.60	4 7	2.24

From the above data it is possible to calculate the times of contact of the bubbles with the solution when the rate of passage of the gas and the depth of liquid are varied. Since the bubble volume was determined at a fairly fast rate, for the purpose of these calculations it has been considered as being independent of the rate of passage of the gas.

As a source of hydrogen chloride, concentrated hydrochloric acid was used. Two washbottles were placed in series in a thermostat at 25.0°C. and purified air from a reservoir under a pressure of about 18 inches of water (kept constant by a water valve) was passed through the acid. The mixed gas then passed after drying and filtering through several centimetres of woolly asbestos in which a thermometer was placed, to a three-way tap and thence through the jet to the vessel containing the alkali solution. Air alone could be sent direct to the above three-way tap by means of another tap. This was often required for flushing out fog still remaining in the absorption vessel after the desired volume of air had been collected in the aspirator. The fog was filtered out of the air by woolly asbestos as previously described (Part 2), the moist air then passing through two $CaCl_2$ tubes. The dry air then passed by a manometer through a con-

stant pressure apparatus to the aspirator. The levels of the liquid in the manometer were kept the same during an experiment. In cases of difficulty in getting this setting, the constant level apparatus was set in operation, water entering until atmospheric pressure was restored; the volume of water which entered was deducted from the volume of water run out of the aspirator. The rate of outflow was checked by a stop-watch in all coses. A filter-pump was arranged so that it could be used for suction from the aspirator, and when this was not desirable the air to be pumped into the reservoir entered through an inlet on the pipe-line. The different absorption vessels were of such sizes that by always using the same volume of solution, "depths" of liquid of 7.5, 5.5, 3.7 cm. respectively were obtained.

To carry out an experiment the three-way taps are opened, so that air only passes through the jets. It is very important to have air passing through while the solution is being poured into the absorption vessel, else liquid enters the jet. After the liquid has all been poured in, the taps are turned off until a bubble of air remains on the tip of the jet. The acid gas is then allowed to pass in at a rate regulated by a tap on the aspirator. The thermometer in the inlet tube gives the temperature of the gas mixture (practically air temperature) and a thermometer in the solution gives the temperatures at the beginning and end of an experiment.

When the "erect" jets were first used difficulties were encountered, owing to the working-back of the liquid into the barrel of the jet and thence to the inlet tap, but by coating the inside surfaces of the jets with paraffin wax this was obviated. The tips of the jets were cleaned, so that a glass surface was exposed for the formation of the bubbles.

The alkali solutions, whether of sodium, potassium or barium hydroxides, were free from carbonate.

In all cases the partial pressure of the hydrogen chloride is taken as 130 mm Although no difference in the amounts of fog formed under similar conditions from moist or dry gas were found, in all cases the gas was dried by calcium chloride.

The fog was analysed by the method previously given. The "partial pressure" of the hydrogen chloride given in the tables has been calculated by taking one mg. of hydrogen chloride as giving a pressure of 0.5014 mm. Hg. at 20°C., or 0.5098 mm. at 25°C. From the increases in weight of the calcium chloride tubes, assuming that water vapour obeys the gas laws, the partial pressures given in the tables were calculated.

In all cases " per cent. H Cl " refers to the percentage of acid by weight in the fog particles. All weights of acid and of fog are given in mg. per litre of air used. The amount of free acid in the particles has been determined in each case as a check on the silver titration, but is not given in the tables.

Owing to the variation of the amount of fog formed with change in concentration of the alkali, it was necessary to use the smallest possible volume of air in the experiments in which the "rate" was altered. Two litres has been adopted as standard, as with this volume the concentration has not been too greatly reduced and a weight of fog sufficient for analysis has been obtained.

(a) *The necessary presence of alkali*: It has been repeatedly observed that in neutral or acid solutions of salts, dyes and colloids, and in distilled water no fogs are formed under the conditions of the present experiments. This is clearly shown also in the data obtained when the effect of alkali concentration on fog formation was being studied—immediately the solution became acid, fog formation ceased.

A number of salts of weak acids were examined also. Solutions of the following (in normal solution generally), sodium acetate, bicarbonate, disodium phosphate, potassium dihydrogen phosphate, and sodium biborate gave no fogs. Thin fogs were obtained with sodium carbonate (IN), and good ones with trisodium phosphate (IN). These results show that a certain hydroxyl-ion concentration is required before fog formation begins.

(b) *Alteration in radius of the jet and in the depth of the liquid*: In practically every case an increase in the radius of the jet causes a greater production of fog. It would appear that at about 5.5 cm. depth the production of fog is at its maximum, for here the two widest jets give considerably more fog, especially at the higher rates, than at either 3.7 cm. or 7.5 cm. With the narrowest jet, there is comparatively little difference in the amount of fog produced at each depth of liquid. With the other jets there is a tendency for less fog to be produced at 3.7 cm. than at 5.5 cm., or 7.5 cm., especially at the higher rates, although the variation is only a few milligrammes per litre of air.

As is noted later, the concentration of acid in the particles is greatest at 3.7 cm., so that the weight of hydrogen chloride escaping absorption decreases as the depth of liquid increases, except for the two widest jets which show maxima at 5.5 cm. On plotting the data obtained, it is found that as the depth of liquid increases and the radius of the jet decreases, the amount of fog formed, and especially the weight of acid vapour escaping absorption tends to vary linearly with the rate of passage of the gas.

(c) *Alteration in rate of passage of the gas*: In all cases any increase in the rate of passage of the gas causes an increase in the amount of fog formed. With the simple aqueous solutions, in general, this increase is not a linear function of the rate. There is evidence that below a certain critical rate the fog production falls off very rapidly, but owing to experimental difficulties, when only small quantities of fog are obtained, it is not certain whether this critical rate exists for solutions containing no colloid or dyestuff.

It may be stated here that the fog formation is not due merely to the comparatively rapid rates at which the gas is bubbled through the solutions, for with gelatine, etc., solutions, a thick fog is formed when only one bubble every one or two seconds passes up through the liquid.

As an example of the results obtained when the radius of the jet and the rate were altered, in Table 2 are given data obtained when a 1.26 N sodium hydroxide solution was used.

TABLE 2.
Depth: 7.5 cm.
Air Temperature: 20—23°C.

Radius of Jet mm.	Rate c c./min.	Fog mg.	H Cl. per cent.	Part. Press. H Cl. mm.	Part. Press H_2O mm.
1.81	200	42.6	9.23	1.99	21.1
	198	42 0	9.22	1.94	16.5
	189	39.5	9.51	1.91	20.7
	170	35.6	9.27	1.68	23.3
	154	31.0	9.24	1.44	16.5
	123	23 9	9.18	1.12	21.6
	108	16.7	9.68	0.81	16.7
1.32	210	45.9	8.70	2.00	19.9
	208	44 8	8 70	1 96	18.0
	181	37.9	8.99	1.71	19.0
	172	36.0	8.18	1.48	19.3
	160	31.8	8.26	1.32	20.0
	125	23.6	8.30	0.99	20.2
	110	19.7	8 56	0.82	18.2

(d) *Alteration in concentration of the alkali*: A large number of experiments have been made in which the same alkali solution has been used until completely neutralized. As shown by the representative data in Table 3, the weight of fog formed has been determined after the passage of each litre of air through the solution. In all cases the fog production falls off as the alkali concentration decreases. As soon as the solution becomes acid, no more fog is formed.

TABLE 3.
Solution: 1.264 N Sodium Hydroxide.
Temperature: 20—22°C.

Depth of Liquid cm.	Rate cc./min	Litres of Air	Radius of Jet. 1.32 mm.	Radius of Jet. 0.82 mm.
3.7	220	0.5	26.1	20.0
		1	27.6 (1.1)	19.4
		2	35.2	36.2
		3	37.3	33.3
		4	29.0	27.5
		5	27.5	23.6
		6	22.4	19.7
		7	20.1	
		8	14.5	
		9	12.8	
		10	8.0	
		11	4.6	
		12	1.8	
7.5	182	0.5	21.1	18.1
		1	19.6	14.3
		2	33.7	26.4
		3	24.5	21.2
		4	15.7	15.5
		5	13.4	13.4
		6	9.7	8.3

Solutions of potassium hydroxide and barium hydroxide give similar results, although at corresponding concentrations less fog is obtained than with sodium hydroxide.

If the logarithms of the mean concentrations of alkali during the passage of each litre of air and of the corresponding weight of fog be taken, a straight line is obtained when they are plotted. Moreover under fixed conditions of depth and original concentration of alkali the lines corresponding to the different jets are parallel.

From the data obtained in these experiments Table 4 is compiled, showing the amount of fog formed in the first litre of air passed through sodium hydroxide solutions of the mean concentrations given at 20°C.

TABLE 4.

Depth of Liquid cm	Radius of Jet mm	Rate c c./min	Mean Concentration of Alkali			
			0.07N	0.26N	0.56N	1.21 N
3.7	1.32	220	14.0	22.2	30.9	49.2
	,,	182	10.8	18.0	26.7	42.5
	0.82	220	9.9	16.4	22.8	39.4
	,,	182	5.6	11.8	19.1	37.4
7.5	1.32	220	11.9	19.4	29.0	49.6
	,,	182	9.6	15.6	22.8	40.7
	0.82	220	7.5	15.3	23.0	42.9
	,,	182	4.8	8.6	15.8	32.4

If these figures are plotted in the ordinary manner it will be seen that in dilute solutions small additions of alkali exert very large effects; in the more concentrated, the amount of fog obtained is almost proportional to the alkali concentration.

The experiments made with the sodium carbonate and trisodium phosphate solutions may now be considered. The data obtained are given in Table 5, the rate being 225 c.c./min., and the depth of liquid 7.5 cm.; at 22°C.

TABLE 5.

Substance	Litres of air	Radius of Jet	
		1.32 mm	0.82 mm
Na_2CO_3	1	9.7	7.9
	2	4.7	3.8
	3	4.1	3.5
	4	0.1	1.0
	5	—	0.2
Na_3PO_4	1	25.5	21.0
	2	11.5	11.0
	3	1.3	0.9
	4	0.0	0.1

There is a rapid fall in the amount of fog formed as the solutions are neutralized. Buffer action may possibly account for the constancy of some of the carbonate figures; the phosphate solution reaches the disodium stage too quickly for the above to be observed, but it doubtless exists in this case also.

Sodium carbonate is not so greatly hydrolyzed as sodium phosphate, and consequently the hydroxyl-ion concentration will be somewhat smaller in the carbonate than in the phosphate solution. This difference is plainly shown by the differences in the amount of fog obtained from the first litre of gas. Now, from the data given in Table 4, the concentrations of free sodium hydroxide which would give the same weight of fog under the same conditions are 0.06 and 0.45 normal respectively; these are of the same order of magnitude as would be expected from the degrees of hydrolysis.

It has not been possible to fix a definite value for the hydroxyl-ion concentration below which no fog appears, but it must be greater than 10^{-5} normal, since the other phosphates and sodium bicarbonate give no fog.

(e) *Effect of the above factors on the concentration of acid in the fog particles*: The acid concentration remains remarkably constant, varying only from 8 to 11 per cent., although the radius of the jet, the rate of passage of the gas, and the depth of the liquid have all been varied. At the two depths, 3.7 cm. and 5.5 cm., for a given rate the concentration of acid is the same; at 7.5 cm. for the same conditions the acid content is about one per cent. lower. At 3.7 cm. the acid content is almost independent of the radius of the jet; in the other cases there is a tendency for the acid content to fall as the radius of the jet is decreased. In all cases there is a slight tendency for the concentration to fall as the rate is reduced.

(f) *Water vapour partial pressures*: In all cases, after making due allowances for differences in temperature, the pressure of the water vapour in the filtered air remains fairly constant at about 95 per cent. of the saturation value for the corresponding air temperature, or 80-90 per cent. of that for the mean temperature of the solution during an experiment. When large quantities of fog are obtained the relations are not so simple, as in some cases values of more than 100 per cent. saturation are obtained. This point is considered later, when dealing with the effect of adding colloids, dyes, etc., to the alkali solutions. With small quantities of fog the vapour pressure is independent of the nature of the solution, the radius of the jet, the depth of the liquid, and the rate of passage of the gas. This presumably shows that the particles attain some sort of equilibrium with the vapour with which they are in contact. This point will be considered more fully when dealing with the sizes of the particles in the fogs.

2. During some of the experiments it was noticed that traces of certain organic compounds exerted a marked positive effect in fog production. For example, in an experiment with a 0.313N sodium hydroxide solution 10 drops of a 0.02 per cent. aqueous solution of methyl red were added, in order to see at what stage all the alkali was neutralized, but much more fog than usual was obtained, namely, 36.7 mg., instead of 22.2 mg. Hence it appeared to be of interest

to obtain strictly quantitative data on the effect of small quantities of colloids or capillary active substances on fog formation.

The following have been used as "capillary active substances": iso-amyl alcohol, sucrose, gelatine, gum arabic, safranine, methylene blue (hydrochloride), congo red, orange G, glycerine, saponin, kaolin, aquadag, and clay.

Solutions or suspensions of these substances in sodium hydroxide were made up, and the amount and the analysis of the fog formed were determined for the different experimental conditions. The analyses given in experiments on the progressive neutralization of the alkali, except where otherwise stated were carried out on the total amount of fog formed, and are therefore average values.

Finally, most of the substances were examined with the conditions of experiment fixed, except for variations in the concentration of the capillary active substance.

Gelatine and Gum Arabic: The solutions were made up by allowing a weighed quantity of the solid to disperse in the alkali solution. Both the gelatine and gum arabic gave no fogs in absence of alkali.

In the case of gelatine solutions of different concentrations were made up, one of which was 0.5N with respect to sodium chloride. It was found that the amount of fog was not very dependent on the concentration of gelatine in the stronger solutions, but even traces of gelatine have a very great effect relative to the amount of fog obtained with a simple aqueous solution. Some of the data are given in Table 6.

TABLE 6.

Solution: 1.24N sodium hydroxide.
Rate: 208 c.c./min.

Per cent	Fog mg	Temp. Air °C	Partial Pressure H_2O mm
0.098	167.3	23.9	19.7
0.082	161.1	25.3	21 2
0.081	153.8	25.1	22.2
0.041	141.4	25.8	21.8
0.041	137.7	24.5	21.7
0.0163	102.9	25.7	22.3
0.0082	81.9	25.3	21.7
0.0032	63.0	25.3	21.9
0.000	47.7	24.9	21.7

Addition of sodium chloride to the solution caused a slight increase in the amount of fog formed.

Small alterations in the concentration of the alkali did not have a great effect on the formation of the fog.

When the rate of passage of the gas was varied, at about 110 c.c./min., the fog production decreased rapidly. This is shown by the data in Table 7. This peculiarity is shown by other solutions also.

TABLE 7.

Solution: 0.275 per cent. gelatine, 0.594N NaOH.

Rate c.c./min.	Air Temp. °C.	Fog. mg.	Per cent. HCl	Partial Pressure H_2O mm.
208	22.7	195.3	10.00	18.7
125	23.5	188.1	7.85	18.5
95	22.9	157.3	8.10	17.7
74	23.7	135.1	7.67	19.8

A number of experiments were carried out at different rates and with different jets and solutions to find out how the fog production varied during the neutralization of the alkali. An example is given in Table 8. The solution was 0.591N sodium hydroxide containing 0.25 per cent. of gum arabic.

TABLE 8.

Depth: 7.5 cm.

Radius of jet: 1.32 mm.

Litres of Air	Air Temp °C.	Rate c.c./min	Fog. mg.	Per cent. HCl.	Partial Pressure H_2O mm
1	22.1	202	143.9	7.99	20 1
2	21.7	199	111 2	7.83	17.4
3	21.4	204	87.5	7.96	18.5
4	21.2	200	65.3	8 18	18 4
5.03	21.3	206	60.2	7 62	16.0

Iso-amyl alcohol, saponin, glycerine and sucrose: The amyl alcohol had a very definite action in increasing the amount of fog. In a 0.594N sodium hydroxide solution containing 1.0 per cent. of alcohol, at a depth of 7.5 cm., the gas being passed at 225 c.c./min., using the jets of radius 1.32 and 0.82 mm., from the first litre of air 79.3 and 83.7 mg. of fog respectively were obtained. Even in 0.01 per cent. solution its effect was quite definite.

Saponin was used in 0.01 per cent. solution. Some difficulty was experienced due to frothing. This solution gave three times as much fog as a simple aqueous solution under similar conditions. The acid content of the particles was somewhat less than in other cases, namely, 6.5-7.0 per cent.

Glycerine and sucrose did not have any effect on the amount of fog formed.

Safranine and methylene blue: Safranine was used in 0.61N sodium hydroxide. It has been found to be of the same order of activity as gelatine. For experimental conditions such that a pure aqueous alkaline solution gave 31.9 mg. of fog, the 0.02, 0.008, 0.0013 per cent. solutions gave 117.9, 83.2, 37.3 mg. respectively. Analysis of the fogs gave a percentage of 8.89 of hydrogen chloride.

Methylene blue was extremely active, so that a dilute solution containing 0.0013 per cent. was used as a stock solution for dilution in some of the experiments. The dye was absorbed very strongly

by all glassware, etc. This property seemed to run parallel with activity in fog formation since safranine and methylene blue were much more strongly absorbed than congo red or orange G.

The same phenomenon was noticed here as with the gelatine solutions, namely, that in the higher concentrations, the chloride in the fog particles was somewhat greater than in the more dilute; for example, the fogs from the strongest solutions gave on analysis 10.2 per cent., and the fogs from the more dilute 8.9 per cent. For quantitative results see Table 21, when it will be seen down to what extreme dilutions the effect of methylene blue can be detected.

Congo red and orange G: Neither of these substances was very active, although the effect of their presence could be detected easily in a 0.0067 per cent. solution. For conditions such that 31.9 mg. of fog were formed from the simple solution, congo red and orange G each in 0.1 per cent. solution gave 71.2 and 90.2 mg. respectively. The percentages of acid were 8.11 and 8.34 per cent. respectively.

Suspensions: Colloidal solutions may be considered as very fine suspensions, so that it is of interest to see what effect a coarse suspension would have on the absorption of the acid vapour. With suspensions of kaolin, graphite (aquadag), and clay, dense fogs were obtained in each case.

Two different concentrations of acid vapour have been used, the partial pressures being 36.7 and 139.2 mm. Experiment has shown that not only is the amount of fog formed, but also is the concentration of acid in the particles very much dependent on the original partial pressure. For example, in a solution containing 0.039 per cent. of aquadag the weights of fog were 88.7 and 129.6 mg. respectively, the corresponding concentrations of acid in the particles being 7.22 and 8.55 per cent. In Table 9 are given some of the results obtained with kaolin. For aquadag, see Table 21.

TABLE 9.

Part Press HCl mm.	Per cent Kaolin	Fog mg	Part Press H_2O mm	Air Temp °C
36.7	1.177	115.0	16.2	22.5
	0.784	84.9	20.5	24.1
	0.392	76.9	22.0	24.2
	0.237	55.9	20.8	23.4
	0.157	47.2	22.0	23.5
	0.000	18.7	22.0	23.7
139.2	0.722	128.8	17.4	21.3
	0.482	110.5	18.6	21.5
	0.241	87.4	16.0	18.5
	0.144	75.2	14.2	17.5
	0.096	59.0	15.4	18.0
	0.048	44.5	15.7	18.5
	0.000	24.2	19.1	21.3

A sample of carefully washed and fractionated Buxton clay was used. The particles were very small, taking some days to settle a few centimetres. This suspension was very active, as is shown by the following figures quoted from the full experimental results.

With a 0.124 per cent. suspension 208.0 mg. of fog obtained, and even with a 0.006 per cent. suspension (which appeared very slightly cloudy to the naked eye) 106.5 mg. of fog were obtained. The mean concentration of acid in the particles was 9.56 per cent.

All the experiments with the suspensions have been carried out under the same conditions namely, with a jet of radius 1.32 mm., and the gas passing at 208 c.c./min., except for the first set of experiments with kaolin, when the rate was 204 c.c./min.

The activity of aquadag approaches, and of Buxton clay exceeds, that of gelatine or safranine, while the kaolin has the same order of activity as congo red.

3. *Hydrobromic acid* has been found to be much more active than hydrochloric acid, this being parallel to its greater "fuming" properties. Neither hydriodic nor nitric acid has yet been tested, but each would doubtless give fogs.

As only a small quantity of hydrobromic acid was available, it was not possible to do many experiments, and, in addition, the partial pressure of the bromide vapour was smaller in each successive experiment; but the partial pressure was estimated in each case.

In all the following experiments the jet of radius 1.32 mm. was used at a depth of 7.5 cm., the gas being passed at 208 c.c./min.

Distilled water gave no fog with a gas in which the partial pressure of the bromide was 79.7 mm. The water vapour partial pressure was 19.4 mm., the air temperature being 21.7°C. This vapour pressure is the same as that found later when fog formation was taking place.

Two different sets of experiments have been carried out using the same concentration of soda (1.26N), but with the fresh solution and the same after the bromide partial pressure had fallen to about 70 per cent. of its original value. It will be noticed that the fog obtained at corresponding intervals in the second set is about two-thirds of that in the first set, so that the production of fog has fallen off almost in proportion to the reduction in the partial pressure of the bromide. The data of these experiments are given in Table 10, the figures in the column headed "mean" being obtained by analysis of the whole of the fog collected, and of the alkali solution at the end of the set of experiments.

TABLE 10.

Part Press H Br. mm. (mean).	Litres of Air.	Fog mg	Per cent. H Br (mean)	Part Press H_2O mm	Air Temp °C
82.4	0.5	47.0		—	21.5
	1	30.4		—	21.5
	2	59.5		20.3	21.7
	3	51.0		20.4	21.7
	4	47.5		20.9	21.9
	5	41.7	21.3	20.6	21.9
56.8	1	50.4		20.1	22.1
	2	43.5		20.2	22.0
	3	34.7		20.5	22.0
	4	34.0	24.9	19.7	22.1

When the same gelatine and gum arabic solutions were used with hydrogen bromide as had been employed with hydrogen chloride, very dense fogs were formed, the bubbles as they passed through the liquid being filled with fog. The concentration of acid in the particles remains practically constant, whether the solution contains any colloid or not.

In Table 11 the data obtained in experiments on the production of fog with progressive neutralization of the alkali are given. In each solution the sodium hydroxide was 0.59N. The "mean" values were obtained as in Table 10.

TABLE 11.

Colloid.	Part Press. H Br mm. (mean).	Litres of Air	Fog mg.	Per cent H Br. (mean).	Part. Press. H_2O mm.	Air Temp. °C
gelatine 0.122 per cent.	59.1	1	180.2		21.2	21.3
		2	164.1		22.0	21.3
		3	132.6		21.6	21 2
		4	106.3	21.8	20.1	21.0
gum arabic .25 per cent.	59.4	1	148.7		18 6	21 5
		2	133.5		20 6	21.6
		3	114 3		20.6	21.7
		4	89.7	21 9	20.4	21.8

The percentages of bromide in the particles are very large; but when these are converted to normalities the concentration is nearly the same as in the case of the chloride, being, in fact, slightly higher. This would appear to show that the particles in each case are of the same size. How far this is true will be seen later when the sizes of the particles are considered.

In the gas, after removal of the particles, the water vapour pressure is constant, and has the same value under corresponding conditions as with hydrogen chloride, although with the gelatine and gum arabic solutions there is a tendency for it to be somewhat greater than in the previous experiments.

If the quantity of fog obtained be plotted as has been done for hydrogen chloride, the same type of curve is obtained. Corresponding to the greater production of fog in these experiments and to the slower falling off as the alkali is neutralized, the lines are not so steep as for hydrogen chloride. It is interesting to note that the lines for gum arabic and gelatine are again practically parallel.

The vapour pressures of the bromide in all these experiments have been considerably lower than with the chloride, yet the amount of fog formed under the same conditions is greater. This is probably due to the lower rate of diffusion of the bromide in the gaseous phase.

4. Although *alcohol* might have been included among the "capillary active" substances, it does not appear to be particularly effective. For example, a 7.6 per cent. solution gives an increase of only about 25 per cent. over the plain aqueous solution of the same alkali con-

centration. The strong alcoholic solutions give dense fogs, which begin to form as the bubbles pass up through the liquid. In this case the presence of a volatile substance lends interest to the experiments.

The solutions used contained 7.6 and 33.0 per cent. by weight of ethyl alcohol, and were 1.223N and 1.238N respectively, with respect to sodium hydroxide.

Alcohol was estimated by the method of Benedict and Norris (*J. Am. Chem. Soc.* 1898, *20,* 293), in which a solution of potassium dichromate in sulphuric acid is used. The procedure finally adopted was as follows. A known volume of the very dilute alcohol solution (0.1 per cent. or less) is run from a burette into a small flask; three times this volume of concentrated sulphuric acid are then added slowly with cooling under a good stream of water. An excess of dichromate solution is slowly added from a burette, after which the flask is heated over a small flame, taking fifteen minutes to reach 98°C., the temperature then being held at this point for five minutes. The flask is then cooled and added to about 300 c.c. of cold water in a large conical flask. After again cooling, the excess of dichromate is destroyed by adding an excess of standard ferrous ammonium sulphate, this excess being in turn estimated with standard permanganate.

The dichromate was standardized by means of a 0.100 per cent. solution of alcohol. This solution was of approximately the same strength as the solutions obtained after extracting the asbestos filters with water.

Since the presence of chloride causes high results, the following procedure was adopted. The asbestos was removed and extracted with distilled water, the volume being kept as small as possible (not more than 100 c c. with the smaller quantities of fog), the washings being run into a graduated flask. An excess of 0.03185N silver sulphate solution was then added, and, after being well shaken the liquid was made up to the mark. After standing for a time, the solution was filtered, and an aliquot taken for analysis. Another portion of the solution was then titrated with ammonium thiocyanate to determine the excess of silver. From the gross amount of alcohol found on analysis a deduction was made for alcohol absorbed by the asbestos, this having been determined in blank experiments.

An attempt has been made to estimate separately the alcohol and the water vapour partial pressures in the gas after the fog particles had been filtered out. The most satisfactory method for the conditions under which it was required to work, appeared to be that of Thomas (*J. Soc. Chem. Ind.,* 1922, *41,* 33T). In this method freshly broken calcium carbide, which must be as free as possible from calcium oxide, is used to remove the water vapour, the alcohol passing on to be obsorbed in concentrated sulphuric acid. The factor for converting the change in weight of the carbide to water was found by blank experiments to be 2.91. Blank experiments showed that no acetylene was absorbed by the acid.

In all the experiments where fogs were formed, the partial pressures were estimated, whence the ratio water/alcohol was calculated, but the results in some cases were somewhat irregular. The ratios

water/alcohol found in the vapour correspond satisfactorily with those given in the standard tables for mixtures similar to those employed in these experiments.

The details of a typical experiment are given:—

Radius of Jet: 0.82 mm.
Depth of Liquid: 7.5 cm.
Solution: 33.0 per cent. alcohol with 1.238N NaOH.
Rate: 159 c.c./min.
Two litres of air were used in the experiment.

Weight of fog per litre of air	0.1132 g.
Carbide, change in weight	0.0149 g.
Equivalent to water	0.0432 g.
Whence partial pressure of water vapour is	22.3 mm.
Sulphuric acid, change in weight ...	0.1062 g.
Whence partial pressure of alcohol is . ..	21.2 mm.

And the ratio $\left\{\frac{\text{weight of water}}{\text{weight of alcohol}}\right\}$ is 0.41

The fog was washed out into a 250 c.c. flask containing 15 c.c. of the silver sulphate solution. After filtering, 100 c.c. of solution required 2.15 c.c. of ammonium thiocyanate solution (equal to the sulphate in concentration) for precipitation of the excess silver; whence the chloride present used 9.63 c.c. of silver solution. This represents 11.18 mg. of hydrogen chloride so that the particles contained 4.94 per cent. by weight of chloride.

For the alcohol estimation two portions of 25 c.c. each were taken, to which were added as described above, 25 c.c. of the chromic solution. To destroy the excess chromic, 10 c.c. of a N/10 ferrous solution were used, for the titration of the excess iron 3.27 c.c. of N/10 permanganate were required; hence the alcohol was oxidised by the equivalent of 10.95 c.c. of the ferrous solution, so that in 250 c.c. of solution there were 109.1 mg. of alcohol (since 1 c.c. of the ferrous solution was equivalent to 0.996 mg. alcohol). The correction for adsorption was 10.3 mg., so that finally the fog contained 98.8 mg. alcohol giving a percentage by weight of 43.6.

Series of experiments similar to those already reported for the other alkaline solutions have been carried out. Some of the results are given in Table 12. It will be noticed that with the weaker solution there is not a great deal of difference in the amounts of fog formed at corresponding rates with the two jets employed; but with the stronger solution the narrower jet gives the greater amount of fog. This has been noticed for the still stronger solution used in Part 2 of these experiments. Also, in the weaker solution, the concentration of acid in the particles approaches much closer to that found with the ordinary aqueous solutions than does that with the stronger solution. In the latter case, the figures are in agreement with those found in Part 2. Owing to the difficulty of preventing liquid from creeping back into the jet, no results could be obtained with the widest jets.

TABLE 12.

Solution: Aqueous alcohol, NaOH 1.23N.
Depth of Liquid: 7.5 cm.
Air Temp.: 20.4-22.5°C.

Alcohol Per Cent.	Radius of Jet mm.	Rate c.c./min.	Fog mg.	HCl Per Cent	Alcohol Per Cent.	Partial Press. mm. Alcohol	Partial Press. mm. H_2O	Ratio Water/Alcohol.
7.6	1.32	191	44.7	8.42	9.40	7.86	24.8	1.23
		154	37.6	7.67	9.51	6.60	19.5	1.16
		149	35.8	7.77	9.76	7.11	22.4	1.23
		118	30.1	7.90	8.75	7.82	21.4	1.07
		101	24.0	10.59	10.85	6.50	21.6	1.24
33.0	0.82	222	132.7	5.16	19	18.2	—	—
		195	130.4	5.23	45.0	18.0	24.8	0.54
		192	127.8	5.11	44.4	18.2	24.9	0.51
		159	118.8	5.25	43.9	20.4	—	—
		126	113.2	4.94	43.6	21.2	22.3	0.41
		126	112.1	5.02	42.9	21.0	25.7	0.48
		74.5	76.6	4.85	41.8	21.4	20.9	0.36

A peculiarity that was shown by varying the rate of passage of the gas was that although at higher rates the amount of fog was almost proportional to the rate, at the lower rates the amount of fog produced fell off much more rapidly than this straight line law required. The data of the above tables show this.

The fogs produced at each stage of the neutralization of the stronger solution have been analyzed. As found with other solutions, the composition of the particles and of the vapour remains practically constant throughout. The data in Table 13 illustrate this. The composition of the particles and of the vapour remains constant when the rate of passage of the gas is varied as shown by Table 12.

TABLE 13.

Solution: 33.0 per cent. alcohol, NaOH 1.238N.
Depth of Liquid: 7.5 cm.
Rates: 201 and 192 c.c./min. respectively.
Air Temp.: 21-22°C.

Radius of Jet.	Litres of Air.	Fog mg.	HCl Per Cent	Alcohol Per Cent.	Partial Press. mm. Alcohol	Partial Press. mm. Water	Ratio Water/Alcohol.
1.32	1	112.0	6.42	39.0	18.4	24.5	0.52
	2	90.4	6.10	39.1	18.3	21.3	0.45
	3	65.7	6.34	39.4	18.3	22.8	0.48
	4	57.5	6.25	40.0	19.5	23.4	0.47
	5	44.1	6.10	43.8	21.1	25.0	0.46
0.82	1	148.8	5.38	41.5	19.1	—	—
	2	106.8	4.74	41.3	17.3	24.9	0.56
	3	84.7	4.94	40.6	19.1	24.9	0.51
	4	80.8	4.74	38.5	19.6	25.2	0.50
	5	59.0	5.12	39.5	20.9	—	—

N

In connection with these experiments it will be noticed that the percentages of alcohol found in the particles are somewhat greater than those in the original solutions. In view of the work of Kablukow (*Zeit. phys. Chem.* 1903, *46*, 399) it is probable that the composition of the vapour from the alkaline solutions is richer in alcohol than that given by a simple aqueous solution of the same alcohol content. If a correction is applied, assuming that sodium hydroxide will have the same effect on the vapour composition as has potassium iodide, then it is found that the percentage of alcohol to be expected in the liquid in equilibrium with the vapour given off is close to that actually found.

It is well-known that pyridine fumes strongly in the presence of hydrogen chloride, so that it is not surprising that dense fogs are formed when air carrying the acid gas is bubbled through a pyridine solution.

A M/2 solution of pyridine was used. Experiments on the progressive neutralization of the solution showed that fog formation ceased only after the solution became distinctly acid. This is probably due to the hydrolysis of the pyridine salt allowing vapour to be given off to form a fog until a sufficient acid concentration is built up to repress the hydrolysis. The bubbles rising through the liquid were filled with fog, so that in this case, as with some of the other solutions already mentioned, at least part of the non-absorption of the acid would be due to the slow diffusion of the hydrogen chloride condensates and in accord with the known difficulty of removing suspended matter from a gas by bubbling The composition of the particles remained constant during the neutralisation of the base. No determinations of the pyridine content of the particles have been made. Some of the data obtained are given in Table 14

TABLE 14.
Depth of Liquid. 7 5 cm
Radius of Jet: 0 82 mm
Rate: 165 c c./min.

Litres of Air	Air Temp °C	Fog mg	HCl Per Cent	Partial Press H_2O mm
1.02	22.7	405 2	7.25	23 3
2	22.7	352 0	8.17	22 7
3	22.7	326.5	8.22	22.7
4	23 0	202 1	8.33	24.3
5 02	22.8	7 8	–	—

This pyridine solution was also used in experiments in which the rate of passage of the gas was varied. With both the jets employed it was found that at the higher rates, say, above 110 c.c./min., the amount of fog obtained varied linearly with the rate, but below this rate the formation of fog rapidly decreased. (See Table 14 a). In this case also the narrower jet was the better fog producer. From Table 14(a) it will be seen that the acid concentration in the particles falls as the rate decreases, although the water vapour partial pressures remain constant. In some cases the pressure is greater than corresponds to saturation at the given temperatures, but this is probably due to the temperature of the gas being higher than that of the solution, owing to the latent heat of condensation of the water in the large quantities of fog which are obtained.

TABLE 14 (a).
Depth of Liquid: 7 5 cm.
(One litre of air used in each experiment.)

Radius of Jet mm	Rate c c /min	Fog mg.	HCl Per Cent	Air Temp °C	Part Press H_2O mm
	217	357.3	8 54	20.0	18.5
1.32	155	335 0	7.28	20.0	18.0
	99	306.9	6.81	20 7	18.9
	80	245.8	6.70	21.3	18.5
	65.5	188.4	7.46	19.0	19.0
	56.5	142 9	6.62	20.8	20.3
0.82	191	326.9	10.20	22 8	19.8
	149	298 3	8.59	23.4	21.5
	107	239 3	8.28	23.8	21 8
	78 5	160.9	8 35	24.0	21.0
	62.5	126.0	7.46	23 0	20.1

5. (a) *Sizes of the Particles*: The chamber in which the fog was allowed to settle was constructed as follows: An inner cylinder of thin, hard glass was surrounded by a thick outer one, the space between the two being sealed at each end. Wide bore taps were used on the inlet and outlet tubes, in order to eliminate as much as possible contact of the fog with any surfaces with consequent coagulation of the particles. Two narrow slits the length of the cylinder were made in the blackened outside wall; these slits were at right angles, one for the entry of light filtered through a water cell, and the other for observation of the level of the fog column. The space above the fog appeared black, while the fog appeared white, the intensity of the dispersed light being dependent on the density of the fog. Along the last-mentioned slit was placed a calibrated glass scale by means of which the height of the surface of the fog could be read at any time. At each 2 5 cm. the times taken for the surface to fall from the zero mark were read on a stopwatch. The surface of the fog remained level during an experiment, except when the densest fogs were being observed.

The following data have been employed in the Stokes-Cunningham equation used for calculating the radii of the particles from their rates of fall: for aqueous, 7.6 and 33.0 per cent. alcoholic, pyridine, and hydrobromic acid solutions, the radius is calculated from $r = X \sqrt{v}$ where X has the values 8.92, 9.00, 9.23, 8.92, 8.40 $\times 10^{-4}$ respectively, the densities of the respective particles having been taken as 1.04, 1.02, 0.97, 1.04, 1.17.

Experiment showed that the radius was the same at all stages of the neutralization of the solution. But the particles increased somewhat rapidly in size during the time of settling, as the rates of fall were greater near the bottom of the scale than at the top. With the dense fogs the particles appear to be smaller than in the other cases. The radii given in the tables which follow have in such cases been determined from the rate of fall of a separate layer which sometimes appeared, or of the original surface at a later period of the settling process. Table 15 gives the radii of the particles in a number of dense fogs. In the first part of the table the solutions were 0.62N with respect to sodium hydroxide.

TABLE 15.

Substance.	Solution Per Cent.	Radius of Jet mm.	Rate c.c./min.	Temp. °C.	Radius cm. x 10^4
Methylene blue	0.02	1.32	210	25.3	1.62
,,	0.004	1.32	210	24.7	1 41
Gelatine	0.122 with				
	0.5N Na Cl	1.32	210	22.5	1.08
Buxton clay	0.186	1.32	210	25 3	1.19
Pyridine	(M/2)	1 32	208	25.5	0.50—1 16
,,		1 32	115	24.2	0.71—1 22
,,		1.32	77	23.8	—1.19
,,		0.82	208	24 5	0 67—1 20

An examination has also been made of the variations of the radii when the colloid, etc., the radius of the jet, and the rate were altered. In general the particles were larger as the concentration of colloid decreased, as the radius of the jet decreased (rate constant), and as the rate decreased (radius of jet constant). When the colloidal solutions or suspensions were used, the radii were distinctly less than with the ordinary aqueous alkali solutions. This may be seen from Table 16 where the data given are selected as being representative of the many obtained; in all the solutions the alkali was 0.62N sodium hydroxide.

TABLE 16.

Substance	Solution Per Cent	Radius of Jet mm	Rate c c /min.	Temp °C.	Radius cm x 10^4
Gum arabic	0.25	1.32	208	23.8	2.01
		1.32	170	24.2	2.17
		1.32	159	24.0	2.04
		0.82	210	23.4	1.93
		0.82	170	23.8	2.11
Methylene blue	0.10	1.32	210	23.7	2.19
	0.01	1.32	170	23.3	1.90
	0.004	1.32	210	24.2	1.72
	0.004	1.32	170	23.5	2.00
	0.004	0.82	170	21.0	1.80
	0.0008	1.32	210	24.9	2.10
	0.0008	1.32	170	24.8	2.31
Kaolin	0.241	1.32	210	25.2	1.84
	0.144	1.32	210	25.2	2.02
Buxton clay	0.186	1.32	210	25.3	1.96
No added substance		1.32	210	24.0	2.45
		1.32	173	24.0	2.42
		0.82	210	24.5	2.58
		0.82	178	23.2	2.62

With the alcoholic solutions the particles given by the stronger solution were somewhat the smaller. In both cases the particles grow rapidly with very considerable thinning-out of the fog. This rapid growth has been observed previously by Barus (*Carnegie Inst.*, No. 62, 1907, p. 113). In Table 17, "original" and "final" refer to the radii calculated for the beginning and the end of the readings.

TABLE 17.

Size of Particles of Alcoholic Fogs.

Alcohol Per Cent	Rate c.c./min	Radius of Jet mm	Temp. mm °C	Radius cm × 10^4 Original	Final
7.6	212	1.32	24.8	1.81	2.13
7.6	212	0.82	25.0	1.79	2.13
7.6	173	1.32	25.4	1.76	2.14
7.6	173	0.82	25.4	1.79	2.16
33.0	212	1.32	25.3	1.71	2.08
33.0	212	0.82	25.2	1.53	2.15

Hydrobromic acid gave similar results to hydrochloric acid as is shown by the data of Table 18. In all cases the particles are smaller than those obtained under similar conditions with the chloride.

TABLE 18.

Solution	Rate c.c./min	Radius cm × 10^4
1.24N NaOH	208	1.90
"	117	1.78
0.62N NaOH with 0.25 per cent gelatine	208	1.58
" "	173	1.32

From the various data obtained, it appeared that the original size of the particles is possibly of the same order as for fogs from other reactions, namely, 5×10^{-5} cm.: for example, pyridine has given particles of radius $5.0\text{-}7.2 \times 10^{-5}$ cm., methylene blue of 7×10^{-5} cm., and Buxton clay of 10×10^{-5} cm., These have been found to be very unstable, often rapidly increasing to a mean radius of 2×10^{-4} cm. Whether the comparatively large particles found for the ordinary aqueous solutions have grown from such smaller particles it is not possible to say.

It is to be noted that apparently an equilibrium state is reached by the particles, since the vapour pressures and concentration of acid in the droplets remain constant and independent of the condi-

tions of formation whether hydrochloric or hydrobromic acid is used. At a later date it is hoped to follow up this important conclusion.

(b) *Charges on the particles*: An electroscope carefully shielded in a sheet-iron box was connected with a small collector. This consisted of copper gauze wound into a plug about 2 cm. by 1 cm. which was suspended in an earthed tinfoil-coated glass tube, connection with the electroscope being made by a copper wire passing through a sulphur seal. Just below the seal a fine capillary jet through which air was forced, was let into the tube. This device is recommended by Bloch (*Ann. Chim. Phys.* 1911 (8) *22* 370) for use with corrosive fumes and was found very satisfactory; before it was used serious electrical leakage occurred after passing fog through the collector for a short time.

The "natural" leak of the system was determined before, during, and after a set of experiments, the time in minutes taken by the image of the leaf to pass over a standard portion of the scale being observed. This was taken as unity, and the time taken for the leaf to pass over the same portion of the scale in an experiment was expressed as a fraction of that time. The results were considered accurate to within one per cent. The apparatus was checked for sensitivity by observing the effect of passing hydrogen from the action of hydrochloric acid on zinc through the collector; the charges were readily detected.

In no experiment was a deviation of more than two or three per cent. found from the "natural" value, and for what were supposed to be similar conditions the deviations were either positive or negative. Although it cannot be said that the fogs have no charge, yet such a charge if present must be small, as the above statements suggest that no charges were detected with certainty in these experiments.

General Discussion.

It has been already pointed out that the relation between alkali concentration and fog formation in aqueous solutions is a logarithmic one; this deduction is also valid for the "capillary active" and other solutions employed. This treatment of the data showed the comparatively small differences brought about by not too great an alteration in the concentration of the added colloid. It was also shown by plotting these results that the slope of the lines did not vary a great deal with the "capillary active" substance used, e.g., under corresponding conditions the lines for two gelatine solutions, the gum arabic and the amyl alcohol solutions are almost parallel.

It will be seen later that when the alkali concentration is kept constant and the concentration of added substance is varied each substance has its own specific effect, i.e., the slopes of the curves vary greatly with the compound employed.

From the tables given above it will have been observed that the concentration of acid in the particles remains sensibly constant for a given concentration of added material, and is, moreover, nearly

the same as that found for the simple aqueous solutions. When the concentration of active material varies the relations are not so simple. In Table 19 are given some of the results of analysis of fog obtained when the concentration is varied.

TABLE 19.

Substance.	Concn. Per Cent.	Rate c.c./min.	Fog mg.	HCl Per Cent.
Buxton Clay	0.174	178	205.2	9.02
	0 124	178	197.4	8.55
	0 062	180	182 4	9.12
China Clay	0 343	216	79.2	8.32
	0.206	216	61.2	7.83
Methylene blue	0.01	180	225.4	9.38
	0.006	180	215.8	8.72
	0.004	180	187.0	8 97
	0.002	178	161.2	8 60
	0.0008	178	122.8	8.47
	0.0004	178	100.3	8.42

It is seen that the acid content of the particles is not independent of the material used.

From the various data obtained it can be stated that: (1) the concentration of acid in the particles tends to decrease as the concentration of "capillary active" decreases; (2) for a given concentration of "capillary active" substance the acid concentration is independent of the concentration of the soda solution; and (3) the pressure of the water vapour in contact with the particles is constant.

When the data obtained in the experiments with varying concentration of "capillary active" substance are plotted straight lines are formed corresponding to the general equation $\log F = m \log C + K$ in which F is the weight of fog in mg. obtained from the first litre of air used, C is the concentration of added material, and m and K are constants. Except for methylene blue, where it is possible that a curve might be drawn through the points, and for congo red and orange G, where the points corresponding to the most dilute solutions lie off the lines, the above statement is strictly true. In Table 20 are given the values of m and K for the solutions examined, and in Table 21 are given the experimental values, together with the values calculated from graphs for three typical substances. It will be seen that in general the agreement is satisfactory.

TABLE 20.

Substance	Concn of Alkali (N).	m	K
Iso-amyl alcohol	0.59	0.274	1.938
Gelatine	0.61	0.284	2.532
Gelatine	1.24	0.287	2.522
Gelatine + 0.5N NaCl	0 61	0.240	2.504
Methylene blue	0 61	0.218	2.700
Safranine	0 61	0.446	2.852
Congo red	0.61	0.385	2.237
Orange G	0.61	0.370	2.326
Kaolin (1)	0 61	0.508	2.080
Kaolin (2)	0.61	0.385	2.169
Aquadag (1)	0.61	0.286	2.352
Aquadag (2)	0 61	0.390	2.667
Buxton clay	0 61	0.212	2.510

Kaolin and aquadag (1): Partial Pressure of HCl 36.7 mm.
Kaolin and aquadag (2): Partial pressure of HCl 139.2 mm.

TABLE 21.

Substance	Per Cent	Log. mg		Remarks
		Found	Calc	
Gelatine	0.098	171.8	176	The points are scattered on both sides of the line drawn.
	0.073	156.2	162	
	0.052	142 4	147	
	0.049	143.2	145	
	0.024	123.8	118	
	0.008	87.1	87	
	0.0035	70 5	68	
	0.0016	52.9	54.5	
	0.000	23.4	—	
Methylene blue	0.0267	222.8	227	The last two points fall below the values required by the straight line.
	0.0133	195.0	195	
	0.0067	168.1	168	
	0.0027	146.7	138	
	0.0013	117.5	117	
	0.00067	98.1	102	
	0.00027	66.0	83	
	0.0000	31 9	—	
Aquadag (1)	0.194	142.0	141	All the points lie close to the line drawn through them.
	0.130	124.5	126	
	0.065	103.5	103	
	0.039	88.7	89	
	0.026	80.6	79	
	0.013	61.7	65	
	0.000	17.1	—	

The activity of the substances extends over a wide range. The only generalization, however, which it would appear possible to make

is that basic substances (e.g., safranine, methylene-blue) are much more active than others (e.g., gum arabic, congo red).

The great capillary activity of such substances as gelatine and methylene blue has has been noticed in other directions (Donnan *Brit. Assn. Rep.*, 1923, Sect. B. 12), e.g., electromotive force (Sândera *Rec. Trav. Chim.*, 1925, *44*, 480), cataphoresis (van der Grinten *J. Chim. Phys.*, 1926, *23*, 209), water-fall experiments (McTaggart *Phil. Mag.* 1914, *27*, 297). As the relation between the amount of material present and the effect it produces is of the same form as the "adsorption isotherm," it has generally been concluded that adsorption at the interface is the cause of the phenomena.

It is rather remarkable, however, that such great effects should be obtained in the present experiments, since the surface tensions of the solutions differ very little from that of pure water, or from the simple alkali solutions. That surface tension is not the controlling factor, at any rate so far as fog formation is concerned, is shown by the fact that although amyl alcohol causes a great reduction in the surface tension, yet it is not very active as regards fog formation.

The use of pyridine is complicated by its volatility, and this is part of the reason why fog is formed in the bubbles as they pass through the liquid. But if pyridine vapour were passed through acid solutions, the result would be quite different.

This aspect has been examined qualitatively by using solutions of ammonia and of hydrochloric acid of varying concentrations. If a gas bearing the chloride vapour is passed through aqueous ammonia, fogs are formed in all cases, because even in very dilute solutions ammonia has an appreciable partial pressure. If, however, the vapour from even concentrated ammonia be passed through fairly strong hydrochloric acid solutions, no fog is formed until the partial pressure of the chloride rises above its infinitesimally small values in the more dilute solutions. In fact, it is only above about 18 per cent. acid that fogs begin to be formed; even at this stage the partial pressure of the acid vapour is only a fraction of a millimetre. As the concentration is still further increased, the fogs become more and more dense.

The mechanism of the absorption of the acid will now be considered in some detail.

If the data given in Table 1 are used to calculate the times of contact of the bubbles with the solution, it is found that these lie between 0.15 and 0.35 second according to the jet and the rate used. Now the widest jets give the largest bubbles, and these move more slowly through the solution. But calculation shows that allowing for change in volume, due to absorption of the acid vapour, for any pair of jets the ratios of the radii and times of contact are practically the same. This leads to the experimental result that the amounts of fog obtained in simple alkali solutions do not vary a great deal.

According to the two-film theory of gas absorption the equation is $\frac{dw}{dt} = AK\,(Pg - Pi)$

where $\frac{dw}{dt}$ is the rate of increase in weight of material dissolved,

A is the area of the bubble, K is a constant and Pg and Pi are the pressures in the gas film and in the liquid film respectively (Lewis and Whitman *J.I.E.C.*, 1924 *16*, 1215). For hydrogen chloride and bromide Pi is negligible in dilute solutions, hence the equation reduces to $\frac{dw}{dt} = AK\ Pg$. Now $dw = -X\ dp$ where X is a function of the molecular weight of the gas, and dp is the fall in pressure brought about by solution of the weight dw. Hence $\frac{dp}{dt} = \frac{AK\ Pg}{X}$ which gives $\log_e \frac{Po}{Pt} = \frac{AKt}{X}$ where Po and Pt are the pressures at times o and t. Since in these experiments Po is constant, and A is constant for a given jet, the equation reduces to $K - K't = \log_e Pt$ where K and K′ are constants. Again since the concentration of acid in the particles is nearly constant the equation reduces finally to $K'' - K't = \log_e F$ where K″ is a constant and F is the number of mg. of fog per litre of air. This requires a linear relationship between t and $\log_e F$. Experiment agrees with the above theoretical requirement as is shown by the data in Table 22.

Table 22.

Depth of Liquid: 5.5 cm.

Radius of Jet.	Rate c c /min	Time of Contact Second x 10^3	Log_{10} F
1.32	217	224	1 724
	203	225	1.682
	195	227	1.670
	162	230	1.598
	153	231.5	1.564
	147	232	1.540
	127	236	1.422
	118	238	1 371
1.08	220	221	1.667
	187	223	1.588
	170	225.5	1 540
	149	228	1.470
	145	229	1 456
	121	233 5	1.316

The lines drawn from data such as those in Table 22, for the different jets are practically parallel at 3.7 cm. and 5.5 cm., but at 7.5 cm. they become slightly steeper as the radius of the jet increases. Moreover, there is not a great difference between the slopes of the lines whatever the jet or the depth of liquid.

It may be useful to examine briefly the different factors which might be considered in being causative agents in the reduction of the rate of diffusion of the acid vapours into the solutions.

First, surface tension effects may be considered solutions of all alkalis and alkali metal salts raise the surface tension of water against air (*Landolt Börnstein Tabellen* 1923 Edn. 238 *et seq.*), and

when present with amyl alcohol, etc., cause much greater lowering than if the alcohol is there alone (Seith *Zeith. phys. Chem.* 1925, *117*, 257). But, as mentioned above, amyl alcohol is not nearly so active in causing increased fog formation as solutions containing dyes and colloids, the surface tensions of which are not greatly different from the simple solutions (Freundlich and Neumann *Koll. Zeit.* 1908, *3*, 80). Moreover, if alkali is absent from such solutions no fog is formed. This shows that the decreased rate of absorption is bound up with the presence of alkali more than with surface tension effects.

It has been already seen that the gas film is the only one to be considered in the absorption of hydrogen chloride. There is the possibility that the rate of absorption is decreased by the presence of air in the mixture, since it has been found that the absorption of ammonia is very greatly affected in such a case (Kowalke *et al. Chem and Met. Eng.*, 1925, *32*, 506). Thus the rate of absorption from a mixture containing 40 per cent. of ammonia was only one-fiftieth of that for pure ammonia. But if such an effect were a predominant one, then fogs would be expected even in the absence of alkali.

The rate of absorption is also governed by the rate at which diffusion both in the gaseous and in the liquid phases occurs. It is necessary to consider only the liquid phase in detail. Now both hydrions and hydroxylions diffuse much more rapidly in salt solutions than in pure water (Lewis *Syst. of Phys. Chem.*, 1920 *2*, 204) while gases diffuse more slowly, the reduction increasing with increase in concentration of the salt (Barus *Car. Inst. Pub.*, 186, 1913). Here again such an explanation of the fog formation breaks down as fogs would be expected, on the above grounds, in salt solutions.

All considerations of this problem lead to the conclusion that the alkali film is the cause of the decrease in absorption. A somewhat similar problem has been examined by Ledig (*J.I.E.C.*, 1924, *16*, 1231) in the absorption of carbon dioxide by alkaline solutions. Three stages in the absorption were noticed, first a very high initial rate which falls to a second fairly steady rate, and third a much slower rate probably governed by the now lowered partial pressure of the gas. In sodium carbonate the rate of absorption was much lower than in pure water. This was not wholly due to viscosity effects, as a cane sugar solution of equal viscosity absorbed the gas more rapidly than the carbonate. Again, a distinction was noted between potassium and sodium hydroxides, potash being the better absorbent—a fact which agrees with the present experiments that potash gives less fog under similar conditions than soda. Distilled water did not give the high initial rates obtained with alkaline solutions, pointing to the fact that the film around the bubble very rapidly becomes saturated with the gas.

Perhaps something of a similar nature occurs when hydrogen chloride is absorbed, although some explanation is required why no fog forms in the presence of neutral salts. Adsorption effects must be in operation on the surface of the bubble, but there will be a tendency for a fresh water surface to be kept there owing to the nega-

tive adsorption of the ions. Dyes and colloids will be positively adsorbed and will form a film through which diffusion must take place. If, as Alty and others have found (*Proc. Roy. Soc.* 1924, *106*A, 315; 1926 *110*A 178; *Phil. Mag.*, 1914, *27* 297), the bubble is negatively charged then there will be a tendency for negative particles to be attracted into the positively charged side of the double layer, that is, there will be a layer of negatively charged particles in the liquid film round the bubble. Hence basic substances will be more active, independent of, but in conjunction with, adsorption. Since the heavy ions would diffuse more slowly than the hydroxyl ions, the rate of fall of pressure would be less than when they were absent. For some reason the presence of alkali in the solution intensifies very greatly the effect of this film of dye or colloid.

The fact that the vapour pressure remains constant and independent of the amount of fog requires some explanation. In the case of very active substances fog is easily visible in the bubbles as they pass up through the liquid. Once a fog particle is formed it will diffuse very slowly, and hence have very little opportunity of being absorbed by the alkali; but before this particle can form, since the gas mixture is originally dry, water vapour must diffuse rapidly into the bubble. Any such particle formation, or even the formation of molecular aggregates would tend to keep the partial pressure of the water vapour low and hence aid further diffusion of the vapour. The alkaline film with its adsorbed material thus appears to act as a membrane which is much more readily permeable to water vapour than to other gases or ions. That the surface of an alkaline solution may be very efficient in the evaporation of water, more so than a pure water surface, is known technically; also that an alkaline film can be impermeable to gases has been shown by Taylor (*Fuel,* 1926, *5,* 195) who found that a layer of alkaline clay was impervious to the gases formed by decomposition of organic matter underneath it. As the whole system in this case was wet, it was not possible to observe if water vapour could pass readily or not. In this case, colloids would, of course, be present, and would form a layer of adsorbed material at the boundary between the soil and the vegetable matter.

This examination of the different factors shows that around the air bubbles an adsorption layer is formed in the presence of alkalis which does not readily permit the diffusion of the ions formed by the absorption of the acid vapour and thus causes a decrease in the rate of absorption to such an extent that the bubble reaches the surface with some of the acid vapour (in extreme cases up to 12 per cent. of the total) still unabsorbed. Capillary active substances in the solution increase the resistance to diffusion very considerably, although the diffusion of water vapour appears to be increased.

It has been previously pointed out that a common radius would be expected for the particles in the fogs, but the data in the tables given above show that this expectation is not wholly borne out by experiment.

The Stokes-Cunningham equation which, be it noted, gives only an average result for the radius as in general a large number of particles are observed at once, has been used for all types of fogs and fumes whether composed of liquid or solid particles, spherical

or otherwise. It is therefore somewhat remarkable as has been pointed out by Rothmund (*Monats.*, 1918, *39*, 571) that in nearly all cases the radius approximates to 5×10^{5} cm. It has been deduced thermodynamically by Donnan (*Zeit. phys. Chem.*, 1903, *46*, 197) that a critical radius of about 1×10^{-5} cm. should exist, and Lewis (*Syst. of Phys. Chem.*, 1920, *1*, 332) found with oil emulsions that there was a distinct tendency for the particles to approximate to this size. But that the same radius should be found general in aerial colloids is certainly remarkable. This "critical" radius is, of course, found only when the particles have grown spontaneously and have not been formed by artificial methods such as spraying.

A very important point to be considered is the manner of production of the visible particles. It is generally agreed that some nucleus must be present whether a small solid particle (dust mote, salt crystal) or a molecular aggregate (hydrochloric acid). This is perhaps satisfactory for some cases, but does not explain the condensation of, say, ammonium chloride, unless it is granted that a few ions which may be present (and these clouds are generally uncharged) can cause the condensation of immense numbers of particles. Indeed, Aitken (*Proc. Roy. Soc. Ed.*, 1916-17, *37*, 215) has concluded that there is no evidence to show that ions of themselves ever act as nuclei—it is necessary that they be combined with an aggregate of molecules of vapour or a dust mote to form a "large ion" before condensation can occur. From a review of the literature it would appear that much more work is necessary before it will be possible to say how condensation occurs, and still more work is necessary to explain the stability of the particles, a subject which is briefly discussed in the next paragraph.

Rothmund (*l.c.*) has used an approximate form of the equation connecting vapour pressure with the radius of curvature of a small particle in conjunction with the van't Hoff equation for the reduction in vapour pressure of dilute solutions, obtaining finally for water particles, the equation $r = 6.1 \times 10^{-6}/ci$ cm. in which r is the radius of a particle with a concentration c of dissolved material, i being the van't Hoff factor. With Rothmund's ozone fogs the formula gives results of the right order. The concentration of dissolved material was very small, 0.03 to 0.08 molar. When, however, the equation is applied to the results of others and of the present author, the results are hopeless. It has been pointed out above how remarkably close to a constant radius all fog particles tend to get, although in many cases the droplets must consist of very concentrated solutions. Moreover, the equation by its derivation does not allow of the existence of a fog in a highly unsaturated atmosphere when the particles consist of dilute solutions of dissolved substances; although it has been observed repeatedly by many workers that chemical fogs can readily form and exist for long periods in such an atmosphere.

At present there is too little information in the literature to enable much progress to be made and what information there is, is rendered almost useless by the fact that in no papers known to the present author have the concentration of dissolved material in the particles and their radii, the vapour pressure of the water in the

gas and its temperature have been given together; in fact, in practically all cases only one of the above is given for the particular fog. It would appear that until all such information is given for all fogs experimented with, very little progress can be made in giving an explanation of their stability.

It is admittedly difficult to apply equations strictly to the fogs, owing to their continual change; but with some of the methods now available for the examination of clouds and smokes considerable progress should be possible.

It is a well-known fact that during the rupture of masses of materials whether solid of liquid very large quantities of electricity are generated. This is particularly so with solids (Beyersdorfer *Staubexplosionen,* 1925, 10, *et seq.*), but even with liquids it is quite considerable. It has been shown that the mere making of new surfaces is not sufficient for this purpose—the extension must be large and very rapid. Hence it may be expected that in chemical fogs charged particles might make their appearance. This expectation is to some extent borne out in practice, but generally only in such cases where violent reactions or high temperatures or other secondary methods of charging have been employed (de Broglie and Brizard *C.R.* 1909, *148,* 1457; *149,* 923). For example, in the metallic clouds formed in the electric arc charged particles are present, but usually the positive and negative charges are equal in number (Whytlaw-Gray *Nature,* 1926, *117,* 201); the vapours of phosphorus and of sulphur contain charged particles (Przibram *Phys. Zeit.*, 1911, *12,* 260); and corresponding to the third possibility given above Remy (*Zeit. anorg. Chem.*, 1924, *139,* 69) found that an uncharged fog became charged on bubbling through aqueous salt solutions, a not unexpected result in view of the work of Kösters (*Ann. d. Phys.*, 1899, *69,* 12) who found that the presence of dust or liquid particles increased the charge carried off by a gas during bubbling.

This last is the most likely source of electrical charges in the present experiments. It has been shown by a number of workers (e.g., Becker *Jahr. d. Rad.*, 1912, *9,* 52; Coehn and Mozer *Ann. d. Phys.*, 1914, *43* 1048) that gases become charged on being bubbled through salt solutions. In such a charged gas it is possible that condensation might be aided by the presence of ions (but remember Aitken's statement above). Now since with some solutions extremely dense fogs have been obtained it would be necessary to assume, if condensation were occurring on ions, that the dyes, colloids, and suspended materials conferred on the liquid the property of causing much greater charges to escape into the gas, since presumably each particle would be the result of condensation on at least one ion. In waterfall experiments some of the dyes have the property of reversing the sign of the charge on the gas, but in view of Vincent's results (*Proc. Camb. Phil. Soc.*, 1904, *12* 305) this would not be very important, if any such reversal were to occur in the case of bubbling. Other work, however, points to the above suppositions being untrue, Bloch (*Ann. Chim. Phys.*, 1911, *23,* 28) found that many substances including acetone, ethyl alcohol, amyl alcohol and hydrocarbons, when present either in solution or as layers on the surface of a liquid greatly depress or even completely inhibit the charging of a gas by bubbling.

It has been shown by the present author that acetone, ethyl and amyl alcohols, increase and not decrease the amount of fog obtained; and it has been observed also that a layer of benzol on the surface of an alkaline solution has no visible effect on the amount of fog produced. There is, moreover, the fact to be considered that in the absence of alkali fog is never obtained with any of the above solutions.

The magnitude of the charge received by a gas during bubbling depends on the radius of the bubble (Bloch *Ann. Chim. Phys.*, 1911, (8), *22*, 370, 441; Fischer *Wien. Ber.*, 1902, *111*, 2 (a), 1,013), the smaller the bubble the greater the charge. But all the jets used in the present experiments are larger than the maximum size for any definite charging of the gas.

From the above survey, therefore, it would appear improbable that any charges would be found on the fogs formed in the present series of experiments, and this is borne out by experiment.

A New Species of Fossil *Arctocephalus* from Cape Kidnappers.

By J. Allan Berry, M.B., M.S.

[*Read before the Hawke's Bay Philosophical Society, 20th August, 1926; received by Editor, 9th March, 1928; issued separately, May 30th, 1928.*]

Plate 33.

The fragments of bone and the teeth which are about to be described were found some years ago by the late Mr. W. D. Southcott, of Hastings, at a spot a little beyond the Black Reef on the way to Cape Kidnappers. They were imbedded in a cliff face about 20 ft. above sea-level and were overlain by about 200 ft. of shingle conglomerate. These deposits may provisionally be regarded as of early Pleistocene Age. The specimens were sent by Mr. H. Hill, of Napier, to the authorities of the Dominion Museum in Wellington, who very kindly placed them at my disposal for examination. Some of the differences noted in comparison with the adult skulls of the species *Arctocephalus Hookeri,* to which it is allied may be due to the fact that the fragments obviously belonged to a young, and possibly a female animal. Not enough material was available to determine what differences sex and age have in altering the various characteristics of the skulls of recent seals so that accurate comparisons could be made.

Fig. 1 is an X-Ray photograph of the fragments with the teeth in position.

Fig. 2 is an X-Ray photograph of the mandible of a female *Arctocephalus Hookeri* kindly lent me by the Dominion Museum authorities, and with which comparisons are made in the course of this paper.

The main fragment is a portion of the left mandible, which is incomplete anteriorly, being broken off obliquely downwards and forwards in front of the third post-canine tooth. It bears the three posterior teeth in position, and the fractured surface has exposed part of the alveolus for the second post-canine, and also part of the alveolus for a large canine tooth. The general shape and proportions of the mandible resemble somewhat that of *Arctocephalus Hookeri.* The jaw is smaller, is less markedly curved, and from the shape and size of the canines the symphysis and anterior portion must have been much more vertically placed. As will be seen from the X-Ray figure, the bone-tissue of the alveolus of the canine is denser and more sclerotic in appearance than in *Arctocephalus Hookeri,* due to the heavier strains that it would have to meet, although relatively to the size of the teeth the bone is extremely fragile. The coronoid process is relatively less in height, and its posterior border, which has suffered abrasion, formed a more obtuse angle with the apex, which is also much less rounded than in the *Arctocephalus Hookeri* shown

Fig 1—X Ray photograph of fragments of *Arctocephalus caninus* n sp

Fig 2.—X-Ray photograph of mandible of *Arctocephalus Hookeri* from Dominion Museum

in Fig. 2. The post-condyloid process is more sharply marked. There are several mental foramina, the largest apparently lying between the second and third post-canines, instead of between the first and second post-canines, as is constant in *Arctocephalus Hookeri.* These foramina lie nearer the alveolar border than in adult animals.

Portion of the left maxilla is present and bears a canine and two post-canines. It has been broken off through a line of fracture that is frequent in recent skulls, viz., from within the nasal cavity posterior to the root of the canine, downwards and backwards to between the third and fourth post-canines. The general appearance shows a much steeper angle than in *Arctocephalus Hookeri.* The mesial aspect shows a roughened surface for the articulation of the praemaxilla, which is completely missing. The palatal process is present in part, and presents a suggestion of a foramen in the suture line between the praemaxilla and the maxilla, directly medial to the canine tooth. The estimated condylo-praemaxillary length was about 14 cm., while that between the outer borders of the upper canines was 3.8 cm.

Arctocephalus caninus n. sp.

Dentition of Lower Jaw.—From the scattered teeth that were present it was possible to place in series the positions of the lateral incisor, the canine, and the first and second post-canines. These teeth, while on the whole resembling *Arctocephalus Hookeri*, show slight but well-marked differences with the exception of the canine, which is markedly different.

Canine.—This tooth presents not only notable differences in its gross form, but also in its X-Ray appearances. It differs from the canine of the adult *Arctocephalus Hookeri* in being much shorter in relation to its width, and in the enamel crown not being so markedly recurved. The base of the root extends backwards as far as the anterior plane of the third post-canine, whereas in *Arctocephalus Hookeri* it usually ends between the first and second post-canines. From the tip of the tooth to its base along the convex border it measures 4.38 cm. in length. The base is obvoate in section, measuring 1.7 cm. in its antero-posterior diameter and 1.1 cm. in its transverse diameter. The enamel crown has an average length of 2 cm. extending, as is usual, further down on the superior surface than on the inferior surface, and further down on the lateral than on the mesial aspect. The X-Ray shows a large pulp-chamber extending much further towards the tip than in *Arctocephalus Hookeri.* The large size of the pulp-chamber is characteristic of all the teeth, and is probably partly explained by the immaturity of the animal. A characteristic of the genus *Arctocephalus* is the large inferior dental canal in order to provide adequate nourishment for the heavy dental battery. In this specimen the canal is actually and relatively much larger than in *Arctocephalus Hookeri,* due to the large size of the canine teeth. As is usual, the canal opens towards the upper border of the root. The enamel crown, as has already been mentioned, is not so markedly recurved as in *Arctocephalus Hookeri.*

Post-Canines.—All show the same general characteristics as in *Arctocephalus Hookeri.* The height and width of the enamel crown is actually somewhat greater, and the length of root considerably less, than in the *Arctocephalus Hookeri* of Fig. 2. This latter relationship is due to immaturity. The principal cusps are similar, and they all possess a well-defined beaded cingulum. All have a distinct anterior accessory cusp particularly well marked in the three posterior teeth. these cusps become larger as they are traced backwards, and are directed almost horizontally forwards and inwards, whereas in *Arctocephalus Hookeri* they are directed upwards and tend to be recurved towards the principal cusp. The posterior accessory cusp is missing in the first and second post-canines, is definitely marked on the third post-canine (it is usually absent in *Arctocephalus Hookeri*); there is only a suggestion of its presence on the fourth post-canine, as in *Arctocephalus Hookeri*; and on the fifth post-canine it is large and well defined. The root of the first post-canine is single, the root of the second is double and has a longitudinal groove on its lateral aspect; while the third and fourth, which were imbedded in the bone, show evidence, on X-Ray examination, of similar grooves. The fifth post-canine shows two separate roots in addition, the anterior one directed forwards (as is usual in the *Arctocephalus Hookeri*), and the posterior one directed downwards and only partially developed. A very noticeable feature of all these teeth is the very large pulp-chamber—the posterior three show distinctly two nerve-roots entering from the inferior dental canal. In addition, the remnants of the dental sacs can be detected.

The lateral incisor is a much longer tooth, both in the root and in the crown than in the *Arctocephalus Hookeri.* It will be noted on referring to Fig. 2 that the vertical axes of the post-canines differ in relation to the long axis of the mandible. The third post-canine is the largest tooth and is almost vertically placed, while the two teeth in front are directed obliquely forward and the two posterior teeth are directed obliquely backwards, the first and last of the series having the greatest degrees of obliquity. The apical third of the anterior root of the last post-canine is curved forwards in relation to the long axis of the tooth and the root of the second post-canine is similarly curved.

In the fossil specimen, Fig. 1, there is only a suggestion of this fan-shaped disposition of the teeth, which is probably largely dependent on their articulation with the teeth of the upper jaw. The heavier teeth in the middle of the series would naturally tend to remain erect, while the smaller anterior and posterior teeth would tend, owing to the greater stress on one border (the teeth articulate by interdigitating), to tilt either in an anterior or in a posterior direction. The degree of inclination would be more pronounced in a mature than in an immature animal. The forward curvature of the roots of the 2nd and 5th post-canines may be explained by the forward growth of the mandible carrying the partially calcified roots with it. The alveolar process develops with the eruption of the teeth, and the erupted crowns consequently would not be influenced by the forward growth of the jaw to the same extent as the roots. The roots of the several teeth would be affected by this forward growth

in varying degrees, according to their position relative to the ossific centres of the mandible.

Dentition of Upper Jaw.—The canine has the same general shape as the lower canine, but its curve is less marked and it is somewhat smaller. The width at the alveolar border is 1 cm., and the length of the enamel crown 2.2 cm. The first and second post-canines present slight anterior cusps, as in *Arctocephalus Hookeri.* There is a slight diastema between the second and third post-canines, smaller than is usually present in adult *Arctocephalus Hookeri.* The two lateral incisors of the praemaxilla are also present. They are caniniform in character and present the same peculiarities as the canines. They measure 3 cm. in length, 1 cm. antero-posteriorly at the base, and 1.8 cm. transversely. Three other teeth are present—the lower canine of the right side, the second lower post-canine of the same side, and also the fifth left upper post-canine This latter tooth is very similar to *Arctocephalus Hookeri,* but the accessory cusps are much more marked. All these teeth are the same in having very large pulp chambers, and a similar dental canal to that in the mandible. The dental formation may safely be assumed to have been—

$$I\ \frac{3}{2}\quad C\ \frac{1}{1}\quad PC\ \frac{6}{5}\qquad \frac{6}{5}$$

Articulation.—As would be expected from the shape of the teeth, the articulation presents marked differences from *Arctocephalus Hookeri.* On close examination of the enamel-crown on the outer aspect of the ridge which normally forms a border on the labio-distal aspect of the lower canine, is an area of attrition of about 2 mm. in length, and about 3 mm. from the tip of the tooth. On the labio-medial aspect of the corresponding upper canine is an area of attrition of about the same size, shape, and position. The lateral incisors of the upper jaw present slight areas of attrition on their mesial aspects close to the alveolar margins. On the lower incisor there is a corresponding attrition mark on the lateral aspect

The various fragments described were submitted to Professor Wood-Jones, who agreed that they belonged to a new and distinct species of seal, for which the name *Arctocephalus caninus* is proposed.

The main points which differentiate this species are the shape of the snout which must have been much blunter than the modern New Zealand hair-seal and the canines which with the slighter differences in the other teeth, resulted in a somewhat different articulation. I have reason to believe that remains of fossil seals, although very rare in other parts of the world, are not uncommon in New Zealand, and that before long one may expect to find more complete remains on which to base a fuller description of this animal.

My thanks are due to Mr. A. R. Ford, B.D.S., for useful suggestions in preparing this paper.

FURTHER NOTE.—Members who prefer to have the four parts delivered as one volume at the end of the year (and not in parts quarterly) will please notify their Secretary to that effect, and pay him the sum of 1/- to cover storage, etc., when the quarterly parts will be held for him, and issued bound on completion of the volume. If no note is received from the Secretary, it will be assumed that quarterly numbers are preferred as issued. Members taking their numbers quarterly may if they wish at the end of the year send them to Messrs. Ferguson and Osborn, who will bind them up in the style of the former annual volume at a charge of 5/6 plus 8d. postage.

ISSUED 31st AUGUST, 1928

TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

VOL. 59.

(QUARTERLY ISSUE)

Part 2, JUNE, 1928.

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

ISSUED 31st AUGUST, 1928

Wellington, N.Z.

FERGUSON & OSBORN LTD., 202 LAMBTON QUAY

WHELDON & WESLEY, Ltd., 2, 3, and 4 Arthur Street, New Oxford Street, London W C

CONTENTS

PART 2, JUNE, 1928.

BOTANY.

CHEMISTRY.

GEOLOGY.

ZOOLOGY.

ABSTRACTS.

LIST OF PLATES.

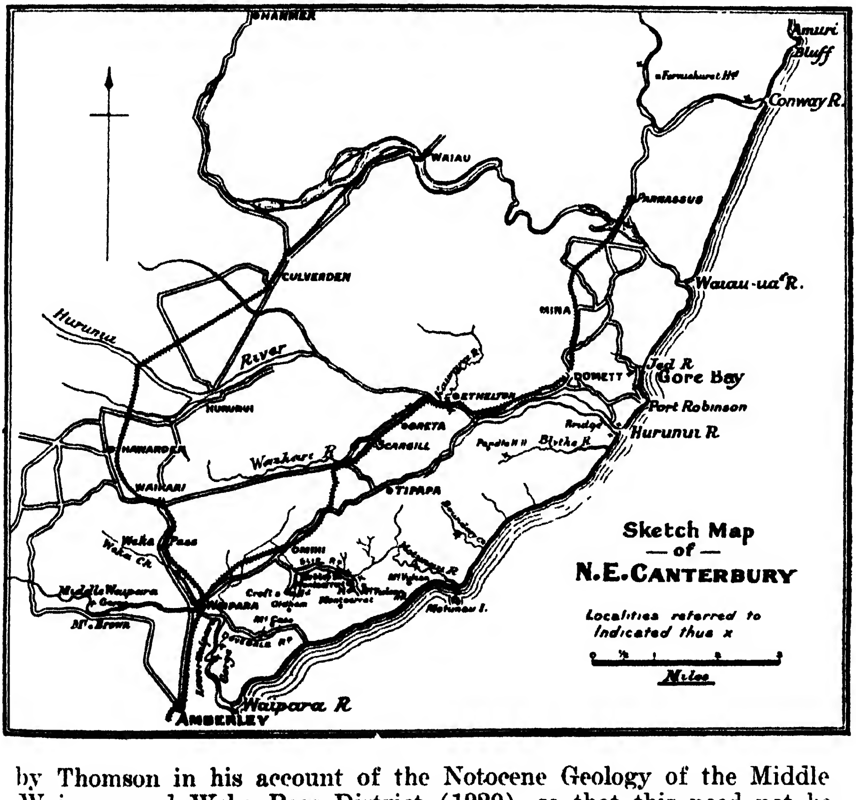
A Definite Break in the Tertiary Sequence in North Canterbury.

By R. SPEIGHT, M.Sc., F.G.S., and GEO. JOBBERNS, M.A.

[*Read before the Philosophical Institute of Canterbury, 7th December, 1927; received by Editor, 9th March, 1928; issued separately, 10th August, 1928.*]

PLATES 34-37.

THE question of the conformity or otherwise of the Cretaceous to Upper Tertiary sequence in North Canterbury has been under consideration since the beginning of the geological investigation of the province, and it still presents points for discussion. The general statement of the case has been given in the paper by Marshall, Speight, and Cotton on the Younger Rock Series of New Zealand (1911), and the matter has been referred to by Morgan (1916) and



by Thomson in his account of the Notocene Geology of the Middle Waipara and Weka Pass District (1920), so that this need not be recapitulated. The present authors in the course of an examination of the shore-platforms in the vicinity of the mouth of the Hurunui came across an unconformity of which the evidence is so clear as

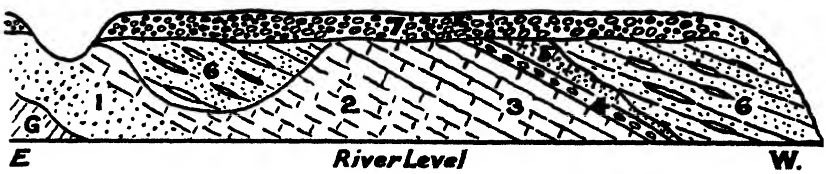
to leave no room for doubt, and this has prompted them to examine other localities in order to see if there is evidence of a break in a similar stratigraphical position. Such evidence has been found as indicates that the break is not a mere local feature, and the localities where it occurs will be taken in turn, commencing with that where the unconformity was first clearly detected.

Mouth of the Hurunui.
(Sections 1, 2, and Figs. 1, 2, 3.)

The only reference to the geological features of this spot is to be found in the paper by Speight and Wild on the Relationship of the Weka Pass Stone to the Amuri Limestone (1918) where a brief account of the beds occurring there is given. Very fortunately, on the occasion of the last visit of the present authors the river had swung away from the right bank above the bridge and thus they were able to get a clear view of the sequence of beds in the locality (Fig. 1).

Lying unconformably on the greywacke are the following beds in ascending order, all striking N.-S. and dipping W. at angles of about 15°. (Section 1.)

1. *Calcareous Greensand*, very glauconitic and with discontinuous calcareous layers and nodules running through it, resting unconformably on greywacke, and passing up into No. 2.
2. *Sandy, Argillaceous Limestone*, i.e., a sandy marl, hard, tinted a greyish green, distinctly glauconitic.
3. *Amuri Limestone*, the top layers showing the characteristic jointed stone passing down into flaky limestone with flaky argillaceous layers of finer texture, occasionally faulted.
4. The '*Nodular Layer*,' of Speight and Wild (1918).
5. *Calcareous Greensand*, the glauconitic facies of the Amuri Limestone.



Section 1.

Hurunui River, South Bank, above lowest bridge. Length—About 100 yards. 1. Calcareous Greensands. 2. Sandy Marl. 3. Amuri Limestone. 4. Nodular Layer. 5. Calcareous Greensands. 6. Sands with Concretionary Layers. Mt. Brown Beds. 7. Terrace Gravels. G. Greywacke.

6. *Sands*, with concretionary layers and nodules, at times argillaceous, usually brown in colour, but with occasionally greenish layers. The sands are at times finely laminated, and are decidedly glauconitic immediately above the contact with the lower bed, where there are included pebbles and boulders of Amuri Limestone. They are very thick and underlie the greenish marls which form the beds under the Hurunui-Cheviot basin, i.e., the Greta Marls, whether conformably or not could not be determined.

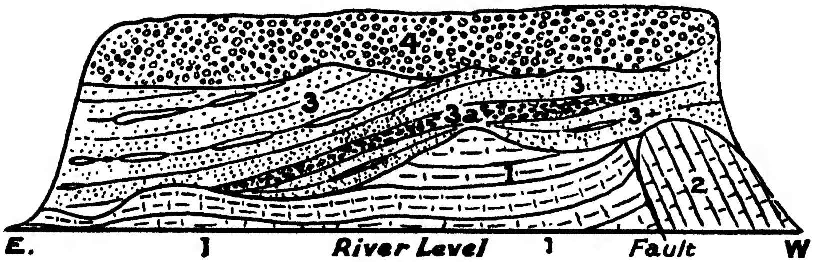
This description of the sequence differs slightly from that of Speight and Wild, chiefly as regards the beds under the Amuri Limestone. What was thought by them to be sands in position at the base of the series resting on the greywacke proves to be a detached mass of No. 6, resting unconformably on No. 2 with boulders of limestone at its base close down to river level. The present position of the stream has enabled this point to be settled definitely.

The same series is exposed on the opposite bank of the river slightly further upstream, but the most interesting section is to be found on the cliffs at the south side of the mouth of the river.

The following sequence is exposed here (see section No. 2, also Fig. 2).

1. *Marly beds*, flaky in texture, the usual facies below the Amuri Limestone in this locality, well stratified, with the beds slightly folded.
2. *Sands,* brown in colour, with marked concretionary masses and layers in their upper portion but comparatively free from them in their lower levels. They rest on the denuded edge of the marly beds, and do not show any sign of their folding. About 7 ft. above the break there lies a bed composed chiefly of boulders and fragments of Amuri Limestone and occasional masses of marly greensand.

   These beds are overlain by gravels, which attain great thickness a few hundred yards away to the south, and are probably the Kowai Gravels. These are in turn capped by recent terrace gravels.



SECTION 2.

Hurunui River, South Bank, at Mouth. Length—About one chain.

1. Marly Beds. 2. Amuri Limestone. 3. Sands with Concretionary layers. Mt. Brown Beds. 3a. Fragments of Limestone and Marly Greensand. 4. Gravels.

The length of the section is about a chain, and at the upstream end there is a mass of Amuri Limestone which has been thrust up into the marls so that their ends are bent up by the movement, and the surface of the limestone slickensided. The fault is a reversed one and does not affect to the slightest extent the overlying beds numbered 3. The mass of limestone shows a bed of phosphatic nodules 18″ thick, but it is quickly cut off by the river.

For some little distance upstream the cliffs are difficult of access and the section obscured, but in a gully coming in from the south

there is an excellent section across the strike. The sequence here is as follows:—

1. *Limestone,* with flaky facies forming the lowest exposed bed. On this rest with an erosion surface
2. *Sands,* irregular in thickness varying from 0 up to 5 ft., containing fragments of Amuri Limestone. On this with marked erosion surface rest
3. *Sands* enclosing fragments, angular boulders, and large masses, up to 20 ft. in length, of Amuri Limestone, very rudely stratified. The fragments are of both facies of the limestone, i.e., those in which the jointing is (i) quadrangular and (ii) flaky (Fig. 3).
4. *Sand,* irregular in thickness.
5. *Fragmental layer.*
6. *Phosphatic nodular band,* very well developed, sometimes splitting into two with a thin layer of sand intercalated.
7. *Thick beds of sand,* with hard calcareous bands and nodular concretions.
8. Capped unconformably with Kawai Gravels.

All the beds No. 1 to 7, strike E.-W. and dip S. at low angles.

In the big floaters of No. 3 are fragments of the phosphatic horizon. It cannot be asserted for certain whether or not the bands of phosphatic nodules are in places a re-concentrate of those formed at a lower level as a result of erosion.

At the head of the gully is a waterfall, below which there is a fault which affects the two facies of Amuri Limestone but not the sands above. The two levels of sand with interstratified large masses are a counterpart of the beds seen on the cliff further downstream. Further upstream the banks of the river are inaccessible except by means of a boat, but when viewed from the bed of the river opposite they show a definite erosion contact.

The evidence in this case in favour of unconformity may be summarized as follows:—1, The upper set of beds rests on a clear erosion surface; 2, The upper set of beds contains numerous and large fragments of the lower set; 3, The latter are folded while the former are not; and 4, Faults affecting the lower set stop short on the line of junction of the two sets. This is convincing, and we do not know what more can be demanded except palaeontological evidence, which unfortunately we cannot supply as we saw no fossils in any of the exposures we examined.

On the opposite side of the river the evidence is equally clear. Just below the bridge on the bank of the river are marls with harder bands of limestone interstratified, dipping S.E. at angles of from 5° to 10°, and these are overlaid unconformably by sands, with calcareous concretionary layers and nodules, the kernels of the nodules being at times formed of Amuri Limestone and occasionally of a greyish marl. There is a cemented band of calcareous sandstone on the contact, which looks in places like a fault, but if so it does not affect the upper set of beds, and the evidence is on the whole against faulting being the cause of the occurrence.

A little further downstream near the plantation at the mouth of the river the relationship of the beds is just the same. Sands.

with concretionary layers are laid on the top of flaky limestone with an erosion surface; large boulders of Amuri Limestone, up to 10 ft. in length, and of calcareous greensand, occur in sandstone, forming quite commonly kernels to the concretions, and angular pebbles form the layer immediately on the contact. In some places the lower set of beds is disturbed by faulting or folding, the faulting being apparently on a line with that on the south side of the river. Very large floaters of limestone, so large that they might be taken after a casual inspection to be actually in position, occur in sandstone on the bank of the river at the upper end of the plantation. The evidence is thus strengthened by an examination of every exposure of these beds in the locality. The only points of importance to be considered are (1), what is the age of the upper set of beds; (2), what is the highest bed of the lower series involved in the break; and (3), does the break occur elsewhere?

In answer to the first question we can only use the test of lithological resemblance and of stratigraphical position. The general character of the beds is the same as that shown by the lower portions of the Mount Brown beds in their type locality. As these are 40 miles apart a correlation based on that alone is perhaps dangerous, but at intervening places, often continuous for miles, there are beds of similar lithological character which have always been correlated by authorities with the Mount Brown beds. Of course similarity in lithological character continuous over a considerable distance does not of itself imply contemporaneity in age, but it establishes a *prima facie* case for consideration. As far as the stratigraphical evidence is concerned we can only point out that the beds at the mouth of the Hurunui underlie the Miocene Marls of the Hurunui-Cheviot basin which are correlated with the Greta or Motunau beds of the Weka Pass area. Concerning these Thomson has remarked (1920, p. 364): "No pebbles of the underlying Notocene beds have been observed, nor has any clear unconformity with the Mount Brown beds been detected, but a faunal break is such that one may well be suspected, and it is more than probable that outside the area an overlap of these beds on the pre-Notocene will be discovered." No contact between these two sets of beds was observed in the Hurunui which could help to solve this problem.

At the eastern base of Pendle Hill, some six miles W.S.W. of the Hurunui mouth, massive shelly conglomerates of undoubted Mount Brown age are seen in the left bank of the Blyth river to overlie the Grey Marls, though the actual contact is not seen here. These conglomerates pass up into soft brown sands precisely similar to those exposed in the south bank of the Hurunui below the bridge, and these sands in turn are overlain by sandy marls of the Motunau series, exposed in the bed of the stream five miles from the sea. From this point the whole of the lower Blyth valley is occupied by thick beds of stratified gravel dipping south-easterly at low angles and unconformable to the Motunau beds.

This exposure must remove any doubts as to the Mount Brown age of the sands at the Hurunui mouth, and it probably enables the gravels to be correlated with those of the Kowai series. Hutton (1877, p. 55) noted the presence of the Pareora formation in the

"north head of the Blyth," and there can be no doubt that these are the beds referred to by him.

In all the exposures at the mouth of the Hurunui the highest bed involved in the erosion-surface is the marly facies of the Amuri Limestone, but boulders of a calcareous slightly glauconitic sand are found above the contact, which proves that the break occurred either after the deposition of the greensand facies of the Amuri Limestone which overlies the ordinary facies, or after the deposition of the "Grey Marl." It is somewhat difficult to distinguish between fragments derived from these two beds seeing that the "Grey Marl" is frequently slightly glauconitic at its junction with the limestone, and it is possible that the greensandy facies of the limestone in one place may be correlated with the grey marl in another.

The last question can be answered by an inspection of other localities where similar beds occur. For this reason a number of places were visited and an account will be given of them in turn.

Port Robinson and Gore Bay.

This locality is only a short distance from the Hurunui mouth, and similar phenomena were expected to be present. This proved to be the case. The beds at Gore Bay have been examined by Haast (1871, pp. 41-44), Speight and Wild (1918, pp. 79-80), and Henderson (1918, pp. 171-4), but no mention is made of the break about to be described. This was discovered when a low tide enabled the point dividing Gore Bay from Port Robinson to be fully examined. The sea cliff rises here from a shore-platform cut in Amuri Limestone and its associated beds, to a former shore-platform at a height of from 230 to 250 ft. Although the sequence cannot be closely examined on the cliff face, a gully a few chains to the north enables the whole to be closely inspected, and the following is the result of an examination of both places, the sequence being in ascending order.

1. Amuri Limestone of the usual facies.
2. *Calcareous Greensand,* passing up into layers of less calcareous material, more glauconitic material with phosphatic nodules at the base.
3. *Greyish sand,* containing small pebbles of Amuri Limestone and of the underlying calcareous greensand, with phosphatic nodules at its lower surface. Its thickness is irregular but with a maximum of 2 ft. It rests on an erosion surface of No. 2.
4. *Sands,* alternating with argillaceous and calcareous beds, so that some layers are pure sand, others sands cemented with calcareous material, others sandy marl. They are more definitely sandy and cemented towards the top while towards the base they are more argillaceous, and with thin bands of cemented material. Their thickness is 150 ft. and they strike N.E.-S.W. and dip N.W. at angles from 15° to 20°.
5. *Gravels* or *Conglomerate,* forming the Gore Bay syncline, composed of rounded pebbles of greywacke, highly oxidized and thoroughly cemented, with a thickness of at least 400 ft. The age of these beds is uncertain, but they have been

assigned to the Pliocene by Haast, while Henderson is doubtful as to their true age.

6. *Sandy Clay,* with interstratified gravels and sands, the gravels thicker and more important at the base (the beds out of which the so-called 'Cathedral' has been eroded), resting unconformably on Nos. 5 and 4.

All the beds above the break appear to be more calcareous when traced across the shore-platform towards the north-east, and No. 3 bed contains "fucoids," so that it may be correlated with the so-called "Grey Marl." Faulting is quite a common phenomenon in the locality.

The exposures on the north-west wing of the syncline on the south side of the Jed are not so satisfactory, but fairly high up on the face of the scarp above the road about half a mile from the beach, there is an occurrence of beds with calcareous concretionary layers containing in places broken shells and small pebbles of Amuri Limestone, so there must be some break between the two sets of beds. No clear contact was seen owing to the surface being masked by slip material, and any conclusion based upon such contacts as are visible under these circumstances must be unreliable. However, such evidence as there is supports the conclusions arrived at from the other wing of the syncline, and thus tends to confirm the conclusions arrived at from a study of the mouth of the Hurunui that there is a definite break between the beds overlying the Amuri Limestone and beds which can be assigned tentatively to the Mount Brown series.

AMURI BLUFF.

This gives no section where a similar contact might be expected.

CONWAY RIVER.

In Haast's account of the beds at the mouth of the Conway reference is made to the occurrence of the "Grey Marl" at the mouth of Limestone Creek. This we were unable to confirm although the place was carefully examined. In our opinion the exposure of sand at the mouth of the creek belongs to the beds exposed on the coast near Hawkeswood further south, and is considerably higher in the Tertiary sequence, and certainly unconformable to the Amuri Limestone on which it apparently rests.

As far as other reaches of the Conway are concerned we can only say that the area is at present under examination by a student, and we do not wish to comment on it further than to say that there are indications of an unconformity between the Amuri Limestone and overlying marly beds in the vicinity of the Ferniehurst Homestead, as recorded already by Haast (1871, pp. 39-40), and Hutton (1878, pp. 39-48).

MOTUNAU.

The contact between the Amuri Limestone and the overlying greensand with the equivalent of the Mount Brown series in the Vulcan Gorge of the Motunau was carefully examined, but no evidence of a break was forthcoming. The conformity of the beds

seems complete, as is recorded in the paper by Marshall, Speight, and Cotton, an opinion which is, however, contrary to that expressed by McKay (1881, pp. 110-3) who places two breaks in the sequence exposed in the Motunau Creek, where we can find none. The only feature which might suggest a break is the fact that some of the faults which affect the Amuri Limestone do not affect the overlying Mount Brown beds, but this evidence is of course very slight and not convincing.

Boundary Creek.

McKay (1881, p. 111) gives a section through the gorge of Boundary Creek, showing an unconformity between his Mount Brown beds and his Pareora series. This conclusion must have been based on the difference of dip of the beds in the gorge and near the old ford across the creek. Probably McKay did not trace the series sufficiently far downstream to note that the dip flattens regularly till, in the vicinity of the ford, the beds are bent up into a syncline to be followed immediately by a gentle anticline, below which they preserve a low south-easterly dip to the sea. There is no apparent unconformity of dip within the Mount Brown series or the overlying Motunau beds.

The exposure of limestone at the top of the gorge is obscured by slips (Speight and Wild, 1918, p. 82) but these do not affect the clear contact shown between a thick layer of marly greensand and the immediately overlying Mount Brown beds. This marly greensand is similar to that exposed in the Motunau River (*loc. cit.* p. 82) and is the local equivalent of the "Grey Marl" overlying the Amuri limestone, which, however, is not seen in position here. Large angular blocks with abundant fucoids lie in the bed of the stream below the slip on the south side, and the exposure in the cliffs a little to the north indicates that the limestone has thinned out very much in this locality.

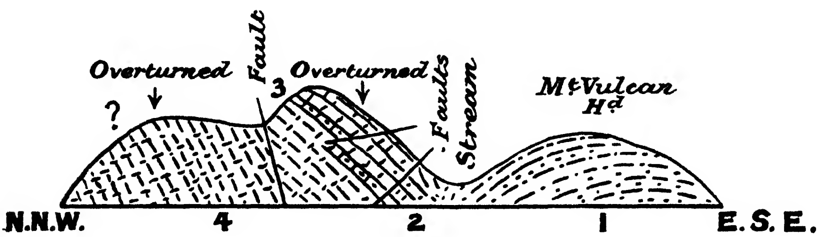
Near the bed of the stream the soft brown sands (Mt. Brown beds) are separated very abruptly from the underlying greensand by a thin well stratified layer of highly oxidized ferruginous sand forming a layer varying from 4 inches to a fraction of an inch in thickness. This layer is not continuous to the top of the cliff, the brown sands being penetrated by a wedge-shaped mass of the marly greensand. Nodular fragments of ferruginous material occur sparingly in the upper few inches of the marly greensand. The Mount Brown beds strike N.E.-S.W. (mag.) and dip S.E. at 20°.

Motunau River, South Branch.
(Sections 3, 4 and Fig. 4.)

The South Branch of the Motunau River near the Mount Vulcan Homestead affords further evidence. A section is given by McKay (1881, p. 117), and while we are in general agreement with his interpretation of the locality our opinion is divergent from his in several particulars. The Homestead of the station is placed on a hill composed of Upper Cretaceous sands dipping south-east, but a little to the north-west of the house the dip changes gradually to northwest, i.e., the house is placed near the axis of an anticline.

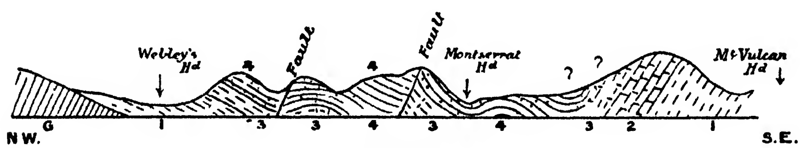
The dip is gentle at first, but it becomes more and more steep till at the point where a bed of limestone crosses the creek to the north of the house the beds are overturned as shown by McKay. But he gives no details of the section although it appears to us a singularly important one. Our description is as follows:—

The limestone bed as exposed here has a strike in a direction approximately N.E.-S.W. and it apparently dips to the S.E. at an angle of from 60° to 65°. Parts of it show the Amuri facies and again other parts approach the Weka Pass Stone in appearance and are decidedly glauconitic. The limestone has apparently been broken



SECTION 3.

Near Mt. Vulcan Homestead.
1. Cretaceous Sands. 2. Limestones. 3. Calcareous Greensands. 4. Marls.



SECTION 4.

Generalised Section from Black Hills to East of Mt. Vulcan Homestead, across Upper Valley of South Branch of Motunau River, North-east of Main Road. Distance—About 2 miles.
1. Cretaceous Sands. 2. Limestones and Calcareous Greensands. 3. Marls. 4. Sands with Concretionary Layers. Mt. Brown Beds. G. Greywacke.

Sections in Upper Valley of the Motunau River, South Branch.

across by faults running at right angles to the strike so that its north-westerly face forms a series of steps, and slickensided surfaces are common. There has been a considerable amount of local disturbance of the beds as the limestone on the crest of the hills immediately to the north-east and to the south-west has the normal dip, i.e., it forms the north-western wing of a great anticline striking N.E. and S.W.

In contact with the limestone and apparently dipping under it conformably on the north-western side is a bed of calcareous greensand with the usual phosphatic-nodule layer on the contact sparingly developed but still distinct. This greensand bed becomes less and less glaucontic and more and more marly as the distance from the limestone increases and passes up without any apparent break into the marl. Both facies contain fucoids, and the marl contains concretionary layers. In a small gully about a chain away from the limestone is a fault running north-east and on its north-

west side the beds dip more steeply. They consist here of loose brownish sands, and greyish marly beds, i.e., typical "Grey Marl," occasionally concretionary, diping S.E. at high angles and continuing for half a mile towards the old Montserrat homestead. The marls and the sands are interstratified throughout the distance mentioned.

The cross-faults affecting the limestone present some difficulties. As far as one can see they do not affect the marl, and the upper cross-fault exposed on the face of the spur may after all be an erosion surface. If so, then erosion has taken place after the greensand facies has been laid down and the conformity is only apparent. If the phenomenon is due to faulting then, since this does not affect the marl and does affect both the limestone and the calcareous greensand, there is some slight evidence for an unconformity between the calcareous greensand and the marl, although the former apparently passes up gradually into the latter. So much movement, however, has taken place that conclusions based solely on observations at this locality are dangerous, and an accurate inference can be arrived at only in the light of observations elsewhere.

Our tentative opinion of the history of the beds at this spot is therefore as follows. The limestones were laid down conformably on the sands forming the heart of the anticline. They were succeeded apparently conformably after some interval by calcareous greensands. These beds were faulted, perhaps eroded (though this is very doubtful) and marls were deposited on the resulting surface. Then a deformational movement resulted in the beds being folded into an anticline and in the immediate proximity of this spot they were overturned. How far away from the limestone the overturning movement extends we cannot say definitely owing to the absence of exposures. A few hundred yards to the south-west along the strike in the upper basin of the south branch of the Motunau River there is a syncline, and the same is probably true towards the north-east, so that the section where overturning has taken place can only be of short length.

There is one small point to note in conection with the marls, viz., at one place underlying a concretionary layer there is a bed of finely-broken shells containing angular fragments of marl, which suggests a minor break within the limits of the marls. This is entirely analogous to the break seen elsewhere under the Mount Brown beds, but it is not so pronounced.

The clearest prof of unconformity between the marls and the Mount Brown beds occurs in the south branch of the Motunau just above Mr. Webley's house and between it and the Montserrat Homestead. As mentioned above the general structure of the upper basin of this branch of the stream is synclinal, the axis of deformation running north-east and south-west approximately. The two peaks Oldham and Montserrat of the Mount Cass Range both formed of limestone, are the two wings of the syncline, and between them the crest of the range is formed of marls and Mount Brown beds. Along the axis of the syncline north-east from the line of the road the beds are involved in minor folds—anticline and synclines—with occasional faulting. Just opposite the old Mountserrat Homestead there is a well-marked reversed fault with a throw of some 50 feet or more. The general trend of these structural features is parallel

to the direction of the valley, and where the stream cuts across the beds good exposures are to be seen, and especially is this the case between Mr. Webley's house and the old station homestead, and also in the reach of the stream above Mr. Webley's house. The stream has here eroded a deep channel for some distance along the axis of an anticline, so that the contacts between the marl and Mount Brown beds are exposed over a length of about a quarter of a mile.

Wherever the contacts between the two sets of beds can be seen their character is the same. In places bands of rock occur with broken shell-fragments, but in all cases there are pebbles of marl, occasionally forming nuclei to the concretionary layers of the upper set of beds, lying as a rule on a definite erosion-surface. The following description of a contact just above the Montserrat Homestead may be taken as typical:—

1. *Marl*—a sandy calcareous clay, typically grey in colour.
2. *Sandy facies* of No. 1.
3. Bed consisting of *pebbles* and *boulders* of *marl,* up to 2ft. in length, well consolidated, composed almost entirely of boulders, the bed from 2 ft. to 10 ft. in thickness.
4. *Shelly fragments,* with occasional fragments of marl, the layer from 2 ft. to 4 ft. in thickness.
5. Alternating *sands* and *concretionary layers.*

To the north-west of this locality the marls are found to rest on the Cretaceous beds without the intervention of the limestones or greensands, as is the case in the basin of the North Branch of the Motunau just over the ridge from Tipapa. This suggests an unconformity between the marls and the Cretaceous series, but does not affect the contention as regards the conformity or otherwise of the Marls and the Mount Brown beds.

The latter form a well-defined escarpment south of the Omihi-Montserrat road to the west of the area just described. This was not closely examined, but the sections across it in the vicinity of Mr. Croft's house near Omihi were investigated in some detail. In three of the gullies of streams running down through his property there are contacts between the two sets of beds substantially the same as those further east, and the sections here are all the more instructive since there is a occurrence of a complete sequence of beds from sands with black oysters and saurian bones, through limestones, calcareous greensands, and marls, with the usual break dividing them from the overlying Mount Brown beds and the closing beds of Greta marl. The correlation of the Mount Brown beds with beds of similar lithological character and in a similar stratigraphical position can thus be made.

At one of the contacts in a creek west of the homestead there are numerous sharks' teeth (*Isurus desori*) associated with the fragmentary layer. In Smothering Gully, further west still, no proper contact was found where it was expected, but the beds are involved in faulting and away from the zone of disturbance the relationships are obscured by the covering of soil and slip material.

WEKA PASS.

In view of our discoveries at Hurunui a careful examination was made of the contact between the Mount Brown beds and the

"Grey Marl" in the classic and much discussed locality in the Weka Pass, and a definite break was discovered at the spot where it was anticipated it might occur. This is situated at the cliff-face above the Weka Pass Stream. just opposite Mr. Archer's house, near the 43¾-mile post on the railway, and is referred to by Thomson (1920, p. 361, and Plate xxi., Fig. 2). He says concerning it, "The conglomerate rests upon soft grey sandstone, of which the few feet exposed show no bedding, so that the presence of an unconformity cannot be definitely asserted, but the presence of derived fragments of sandstone in the overlying limestone makes it probable." Hutton had placed the break between the "Grey Marl" and the Mount Brown beds at a higher stratigraphical level than we do, at a point about two chains nearer Waipara, but we are of the opinion that the phenomena displayed there are more satisfactorily explained by faulting.

Our description of the occurrence on the cliff-face coincides in general with that of Thomson, except that we do not see the necessity to postulate the presence of a fault to account for the irregularity. Our reasons against the fault are as follows:—(1), There is no evidence of dislocation in the railway-cutting in close proximity nor on the face of the cliff upstream, i.e., the beds are continuous above; (2), the underlying marl is continuous and shows no break; (3), there is no appearance of the sandy facies of the marl at the end of the cliff, which should show if the downthrow were to the north; (4), if faulting is used to explain the contact on the northern side then the downthrow must be to the south since sandstone layers of the Mount Brown beds butt against "Grey Marl."

The section exposed in the railway cutting is as follows:—

1. *Limestone,* sandy, and composed largely of shelly and bryozoan fragments.
2. *Sandy layers* with angular fragments of "Grey Marl," up to 8 inches in diameter, getting finer and finer, through from 10 to 12 feet of thickness, one layer, 18″ thick, being composed almost entirely of fragments. These fragments are visible on both sides of the cutting.
3. *Sandy beds,* with irregular concretionary bands.

These horizons can be traced round the face of the spur and the cliff towards the stream in their proper positions. On the cliff face the "Grey Marl" and its upper sandy facies appear and resting on them are Mount Brown beds with interstratified sandy concretionary bands, the contact being apparently an erosion-surface. At the junction there is a conglomerate composed of rounded and angular fragments of the lower beds, rounded pebbles stained with oxide of iron, and numerous shell-fragments—molluscs, barnacles, bryozoans—as described by Thomson, the whole thoroughly cemented into a hard mass by means of calcium carbonate. The angular fragments are numerous and vary in size up to 4 ft. Part of the face is masked by sinter, and on both sides of the contact are concretionary layers of sand, parallel to the junction, and cemented as similar layers are at the Hurunui.

It seems to us that this occurrence is due first of all to the erosion of the "Grey Marl" and its upper sandy facies, and that a deposit of the upper beds has been laid down on a shore-line where there has been considerable wave-action, for the fossils are rounded and abraded. The character of the contact is practically the same for a couple of chains, and apart from the absence of faulting and folding of the lower beds, is exactly analogous to that at the mouth of the Hurunui. There is also a suggestion of unconformity from the fact that the sandy facies of the marl shows a much less thickness at this spot than further to the north-east, pointing to the existence of an irregular surface which may be due to erosion of the soft incoherent layer.

The evidence is therefore fairly strong that in spite of the agreement of dip and strike of the Mount Brown beds and the "Grey Marls" there is a physical break, but Thomson has come to the conclusion on palaeontological grounds that there is no great faunal break between the two sets of beds.

MIDDLE WAIPARA GORGE.
(Figs. 5, 6.)

This also is an important locality in view of the attention it has attracted. The places likely to give clear contacts being in the river-bed itself and on its banks, these were examined closely, but the only place where the evidence suggests a break occurs at the junction of Boby's Creek with the main stream and just above it. About 150 yards above the junction in the bed of the main stream is a contact analogous to those seen elsewhere Resting on sandy grey marl is a bed of sandy limestone containing numerous remains of finely-comminuted shells with angular fragments of the underlying marl, up to 8 inches in length. This can be traced downstream for over a chain when the river covers the contact (Fig. 5). The beds here strike N.E.-S.W. (mag.) and when followed downstream further there is no appearance of this bed in the bank where it should occur in proper alignment, but about a chain to the south-east there is a clear erosion-surface with masses of marl of large size, i.e., yards in diameter, and also irregular fragments of smaller dimensions grading down into pebbles (Fig. 6). The sequence here is as follows:—

1. *Grey sandy marl,* with occasional concretionary layers, usually in detached masses.
2. *Fragmentary layer,* composed of round and sub-angular fragments and masses of large size from bed No. 1, the lower portion definitely current bedded and composed of smaller rounded fragments.
3. *Calcareous sandy* beds with many harder concretionary layers passing up into the Mount Brown sands and Limestone, the Lower Limestone of Thomson (1920, pp. 357 seq.) These beds contain in their lower portions sandy calcareous layers composed of shells with fragments of marl scattered all through, the layer with shells being exactly analogous to that seen upstream.

The face of this exposure fronting upstream to the Waipara is over 50 ft. high, and we think it must be the same as that referred to by Thomson (*loc. cit.,* pp. 358-9). There has been a considerable change in the river banks owing no doubt to the recent severe floods, and for this reason Thomson was perhaps unable to determine the extent of the break.

We considered the possibility of this break being due to some local and, geologically speaking, fairly recent erosion-phenomenon, and decided against it; but we are of the opinion that this does apply to a great detached mass of Mount Brown limestone which rests against a marly surface also belonging to the Mount Brown series close to this spot in Boby's Creek. It is remarkable, however, that this mass contains numerous fragments of marl as inclusions, which also emphasizes the break between the marl and the Mount Brown beds. There is thus decided evidence of a break without angular unconformity in the series as exposed in the Waipara River, and in such a position as may fit in with the break below the Mount Brown beds elsewhere. This section, however, emphasizes the difficulty of deciding what beds must be included in the Mount Brown Series and what in the "Grey Marls," seeing that there is a close similarity in the lithological character of the beds forming the base of the former and the top of the latter. This is after all not so remarkable since the lower set of beds, especially if they are of soft incoherent character, will naturally furnish a considerable quantity of the material for the upper set and will therefore resemble them more or less closely in lithological features. Thomson notes the similarity of the fauna of the two sets of beds and therefore infers conformity, but without questioning the accuracy of his observations or conclusions we should like to be in a position to know whether the fossils from the "Grey Marl" on which he bases his conclusion, were from above or below the break as it occurs in the Waipara.

Lower Waipara Gorge.

This locality was naturally expected to furnish a contact between the "Grey Marl" and the Mount Brown beds, but an examination of the cliffs below the pronounced loop in the gorge gave no satisfactory evidence. Over beds which were undoubtedly the "Grey Marl," judging by its stratigraphical position, lithological character, and continuity with the "Grey Marl" beds exposed over the limestone on the Dovedale road, lay sandy beds, with well-defined richly fossiliferous concretionary layers, interstratified with which were occasionally sandy marly layers. Owing to the covering of surface-slip the nature of the contact could not be seen. On the upstream side of this loop marls are exposed and apparently involved in some dislocation or discordance, but it is practically certain that these marls represent beds interstratified with the Mount Brown beds, and any conclusion based on their features would be unreliable. However, in a creek coming down from Mount Cass, parallel with the Dovedale road, and entering the Waipara River through a narrow gorge cut across the strike of the beds, there is a very suggestive section.

On the north-western side of this stream along the Dovedale road is the typical development of Amuri Limestone passing up in many places without any definite line of demarcation into the Weka Pass Stone, and over this lies the "Grey Marl" in which the creek has been eroded on the surface of the limestone. On the south-east side of the creek the marl forms cliffs capped by the sandy facies of the marl, and further south-east still occurs the parallel escarpment formed out of Mount Brown beds. Thus the beds show their normal stratigraphical relationship. The creek flows south-west in the marl, practically parallel with the strike, but on approaching the main stream it cuts across the strike, and as the beds are tilted at angles of about 60° a good opportunity is given to study their relations.

On the surface formed out of the sandy facies of the marl lie concretionary gravel beds, showing an abrupt change, with markedly irregular surface, as if eroded on the sandy marls, the contact containing fragments up to 4 ft. in length of the underlying beds. The gravel beds are full of fossils. Of course one must be very careful in postulating unconformity when a gravel bed lies on incoherent material with an irregular under-surface, but a similar contact can be observed in various places along the line of this particular bed, and there is additional evidence of the break from the fact that between this bed and the marl further downstream near the loop of the river referred to above there is a thickness of sands with concretionary fossiliferous layers, amounting to some hundreds of feet, whereas in the locality mentioned above the gravel bed lies directly on the sandy facies of the marl. This indicates overlap, and the inferential unconformity of the upper set of conformable beds with the lower set.

WAIKARI RIVER.

The stratigraphical relationship of the beds exposed in the lower part of the valley of the Waikari Creek was investigated at several points. About a mile above the junction of the stream with the Hurunui River there is the following section:—

1. *Greywacke,* with granitic conglomerate, striking N.E.-S.W. and dipping at high angles, almost vertical.
   Lying unconforably over these are:—
2. *Sands,* yellow to brown, with calcareous concretionary bands.
3. *Greensands,* very glauconitic.
4. *Sands,* light-coloured to yellowish.
5. *Marls,* greyish in colour with harder more calcareous bands, occasionally flaky, more glauconitic in the top layers.
6. Band of *oxidized fragments,* very well defined and covered by an irregular concretionary layer.
7. *Glauconitic marl* with occasional fragments of oxidized material 12in. to 18in. thick.
8. *Sands,* with concretionary layers, i.e., the Mount Brown horizon.

The junction is not so marked as elsewhere and the general texture of the beds suggests somewhat different conditions of deposit, all the beds involved being finer in grain and more marly. However, about half a mile up one of the two creeks opposite the Greta Railway Station, the break is clearly seen. Large rolled fragments of flaky grey marl and of sands from the underlying beds occur at the junction of the Mount Brown beds with the sandy facies of the underlying marl. This is analogous to the phenomena seen elsewhere at this horizon.

There is another case of unconformity at a higher level to be seen in this locality. In the first railway-cutting past the homestead, Greta Marls with fossils (*Turritella*, etc.) are overlain unconformably with gravel-beds containing abundant shell-remains and fragments of Greta Marl near the zone of contact. At the junction of the creek which runs past the homestead and the Waikari Creek the contact is marked by large boulders and angular blocks of the subjacent beds. A suggested tentative correlation of the gravelly bed is with the Kowai Gravels.

Near the Ethelton Railway Bridge.

a. *Hurunui River.*

On the left bank of the Hurunui River just above the junction of the Kaiwarra Stream the following sequence is exposed.

1. *Greywacke*—at mouth of Kaiwarra Stream.
2. *Sands*—grey and yellow sands with concretions, greensands.
3. *Marls*—grey, brecciated and distorted.
4. *Marly greensands.*
5. *Brown* and *grey sands* with hard calcareous bands and concretions (Mt. Brown beds)—these appear 150 yards upstream from the mouth of the Kaiwarra. The upper part of the grey marls is involved in a fault, on which is a small exposure of brecciated limestone—very greensandy. The fault does not disturb the small exposure of marly greensand and the immediately overlying Mount Brown beds, the junction between these being quite clear near the bed of the stream. The lower hard calcareous band of the Mount Brown series shows a flat undersurface pitted with holes from which ferruginous inclusions have weathered. The contact is very similar to that exposed in the lower portion of the Waikari Creek—i.e., the change from the marly greensand to the overlying brown sands is very abrupt and the contact marked by a thin zone of ferruginous matter weathered to a deep brown. Here one large irregularly lenticular inclusion of marly sand occurs 4 ft. above the junction. The sands of the Mount Brown series strike 10° E. of N. (mag.) and dip westerly at 70°, but the dip of the underlying marly greensands, though apparently conformable, cannot be determined with certainty.

Fig. 1.—View of the Hurunui River from near Lower Bridge looking west, and showing Tertiary Beds on left. The beds on the point are Amuri Limestone, Mount Brown Beds are in the middle of the section, and greensands and greywacke under the bush in the foreground.

Fig. 2.—View of the mouth of the Hurunui River, from near bridge, looking east. The limestone and associated marl show up white near river level on both sides of the stream, and the Mount Brown Beds overlying them unconformably are darker in colour. The high cliff is capped with gravel.

Fig. 3.—Mount Brown Beds with included mass of Amuri Limestone on right, view taken in gully on south side of mouth of Hurunui River.

Fig. 4.—Limestones and marls near Mount Vulcan Hd. The limestone is overturned; the marls with concretionary layers show in the gully on the left of the picture. Approximate contact of limestone and marl shown by the line.

FIG. 5.—Contact between Mount Brown Beds and Marls in Middle Waipara Gorge above junction with Boby's Creek. The bed with angular fragments of marl is marked X. This does not appear across the river. The grey material in the middle background is marl capped with recent terrace gravels.

FIG 6 —Mount Brown Beds lying unconformably on marl just above junction with Boby's Creek The large angular masses in the middle of the bluff are of grey marl, which is in position on the right of the picture The bluff is capped with Mount Brown Beds with characteristic concretionary layers, which are also seen on the extreme left.

On the right (south) bank of the river there is no exposure of the beds lying between the greywacke and the Mount Brown beds which here strike a little to the west of north and dip westerly at 70°-75°. They form high bluffs and pass upstream into the grey sands and sandy marls (Greta beds) occupying the main portion of the synclinal basin.

b. *Kaiwarra Stream.*

The same series of beds can be traced upstream from its junction with the Hurunui, viz:—(1) *Greywacke.* (2) *Sands.* (3) *Marls*—lower beds brecciated and disturbed, the upper becoming very greensandy. (4) *Mount Brown beds.*

Some 300 yards upstream from the mouth, the junction between the Mount Brown beds and marly greensands is marked by a thin layer of very ferruginous nodules, the lower calcareous band in the Mount Brown beds being here jointed into quadrangular blocks. Where the first bend of the stream is eroded practically on the strike of the beds, the contact between the Mount Brown sands and the underlying marly greensands is highly irregular. If this area had not been so much disturbed it might have been stated quite definitely that this indicates deposition of the Mount Brown beds on an erosion surface.

SUMMARY AND CONCLUSIONS.

It will be seen from the above descriptions that over a wide area there is evidence of a physical break between the Marl and the Mount Brown beds; only in the Motunau Gorge of all the localities cited is there no evidence of such. Perhaps the evidence is not so strong in the later cases as it is in the case first described, but it is still sufficient. The only proof wanting is that dependent on the fossil-content of the two sets of beds. Unfortunately the "Grey Marl" is somewhat poor in fossils; in many cases none have been recorded, and in the most-studied locality, viz., the Weka Pass and Waipara, there is no evidence of a faunal break; in fact, on the fossil evidence Thomson (1920, pp. 356-363 and 386-396) concluded that the two sets of beds should be grouped together. Hutton (1888, pp. 257-9) considered that they should be separated. It is possible, however, that more complete collecting in localities not yet exploited may support the evidence obtained from physical considerations. A specially favourable locality for this work would be the Lower Waipara Gorge and the tributary coming in from Mount Cass.

There is one aspect of the case which should be considered, viz., the possibility that the contacts just described may after all be normal when a marl, sandy marl, or soft sandstone changes upward to a bed of similar lithological character. We admit that the change of such a bed to a conglomerate or gravel-layer may be attended by interformational erosion, since the change in lithological character implies the onset of conditions where strong currents are operating, depositing coarse material and at the same time causing erosion of

the underlying incoherent beds, but this hardly operates when the change is from one soft bed to another of similar non-resistant material. Also, the reason why such breaks have not been definitely recognized, maybe that the material of the upper set of beds must in many such cases be derived directly from the lower, and hence must resemble it in composition and frequently in texture. However, judging from the form of the fragments in the cases under consideration it is clear that the consolidation of the lower set of beds had taken place before they were subjected to erosion, and this implies a considerable time interval.

There is also the general absence of angular unconformity between the two sets of beds to be accounted for. In some cases, as at the Hurunui mouth and in the South Branch of the Motunau, this does occur, but in general there is no obvious difference in angle between the two sets of beds. This has been commented on by most writers, although Hutton and McKay have insisted on differences which we cannot confirm. This absence of angular unconformity implies that erosion took place as a rule while the beds were lying flat, and that the upper set was also deposited flat and that tilting took place subsequently. It is unreasonable to assume that had tilting taken place in the interval between the depositions the conformity in angle could have been so general. In cases where there is an angular discordance, as at the Hurunui mouth, it is clear that the break took place near an old sea-cliff, cut in the limestones and marls, it being impossible to account for the very large blocks with gravel-beds and rolled shell-fragments in any other way, and it emphasizes the point that the mere presence of large fragments in older beds does not of itself imply glacial conditions unless other evidence of ice-action is there to confirm the supposition. We refer to the supposed glacial conglomerate in the Hokonui Hills as an illustrative example. Such deposits, composed of large blocks of limestone and marl, may be seen now forming at the base of limestone and marl cliffs on various stretches of the present coastline.

Finally, reference has been made to the possibility of a break *below* the "Grey Marl," as indicated in the sections at Port Robinson, and perhaps near the Mount Vulcan Homestead and in the Conway near Ferniehurst, but the question has little relationship to the break at the *top* of the marl, and can be left to future consideration.

In advancing the present hypothesis we understand that it will provoke discussion, especially as one of us has maintained the conformity of our Cretaceous and Tertiary sequence. It is possible that some other explanation of the phenomena we refer to may be advanced, and may indeed be substantiated against us, but we feel that such discussion will result in adding to the general knowledge of the stratigraphical geology of a critical area, and that alone justifies us in submitting the question of the conformity or unconformity of our Tertiary sequence for reconsideration.

REFERENCES.

HAAST, J., 1871. On the Geology of the Amuri District, in the Province of Nelson and Marlborough, *Rep. Geol. Explor. during 1870-1*, pp. 25-46.

HENDERSON, J., 1918. Notes on the Geology of the Cheviot District, *N.Z. Jour. Sci. Tech.* vol. 1., pp. 171-4.

HUTTON, F. W., 1877. Report of the Geology of the North-east Portion of the South Island, *Rep. Geol. Explor. during 1873-4*, pp. 27-58.

„ 1885. On the Geological Position of the Weka Pass Stone, *Q.J.G.S.*, vol. XLI., pp. 266-78.

1888. On Some Railway Cuttings in the Weka Pass. *Trans. N.Z. Inst.*, vol. 20, pp. 257-63.

McKAY, A., 1881. On the Motunau District, Ashley County, *Rep. Geol. Explor. during 1879-80*, pp. 108-16.

MARSHALL, P., SPEIGHT, R., and COTTON, C. A., 1911. The Younger Rock Series of New Zealand, *Trans. N.Z. Inst.*, vol. 43, pp. 378-407.

MORGAN, P. G., 1916. Notes of a Visit to Marlborough and North Canterbury with especial reference to Unconformities post-dating the Amuri Limestones, *10th Ann. Rep.* (n.s.) *N.Z. Geol. Sur., Parl. Paper C.—2B*, pp. 17-29.

„ 1916 (a). Records of Unconformities from Late Cretaceous to Early Miocene in New Zealand, *Trans. N.Z. Inst.*, vol. 48, pp. 1-18.

PARK, J., 1888. On the Geology of the Waipara and Weka Pass Districts, *Rep. Geol. Explor. during 1887-88*, pp. 25-35.

„ 1905. On the Marine Tertiaries of Otago and Canterbury, with special reference of the Relations existing between the Pareora and Oamaru Series. *Trans. N.Z. Inst.*, vol. 37, pp. 489-551.

SPEIGHT, R., and WILD, L. J., 1918. The Stratigraphical Relationship of the Weka Pass Stone and the Amuri Limestone, *Trans. N.Z. Inst.*, vol. 50, pp. 65-93.

SPEIGHT, R., 1912. A Preliminary Account of the Lower Waipara Gorge, *Trans. N.Z. Inst.*, vol. 44, pp. 221-33.

THOMSON, J. ALLAN, 1920. The Notocene Geology of the Middle Waipara and Weka Pass District, North Canterbury, New Zealand, *Trans. N.Z. Inst.*, vol. 52, pp. 322-415.

The Recent Mollusca of the Chatham Islands

(*Most of the material on which this paper is based was collected by the Otago Institute party at the Chathams in the summer of 1924.*)

By H. J. Finlay, D.Sc.

[*Read before the Otago Institute, November 9th, 1926; received by the Editor, 7th May, 1928; issued separately, 10th August, 1928.*]

Plates 38-43.

Collections of shells were early made from this locality, mostly by H. L. Travers. Numerous specimens came into the hands of Captain Hutton, who, in his *Catalogue of the Marine Mollusca of New Zealand*, 1873, was the first to give a connected account of this molluscan fauna. He frequently refers to the Chatham Islands in the distribution of the shells he records, and describes a number of new species which he states occur there alone. This rather scattered list is not substantially altered in the *Manual of New Zealand Mollusca* of 1880, nor in Suter's standard work of the same name (1913), except that the distribution of most species had in the interim been considerably extended, with the result that in the latter work the only two species reported as from this locality alone are the European *Corbula gibba* (which, of course, has no right to appear in any New Zealand list), and *Dentalium opacum* (the identification of which appears to be equally worthless). In contrast to this, some 30 species are noted in the present revision as endemic to the Chathams, and some of these are so characteristic and distinct that only deplorable lumping could merge them with mainland forms. Thus Hutton's statements, fifty years old though they are, have proved substantially correct—a tribute to his good work—and his views on the distribution of many of the Chatham shells were sound. Consideration of these endemic species, and of the relationships of other forms will be dealt with in the summary at the end of this account.

The systematic list itself, which follows, is based as regards order of families and genera, etc., on Hedley's admirable *Check-List of the Mollusca of New South Wales*, 1918, with the necessary emendations noted by Iredale in the *Proc. Linn. Soc. New South Wales*, vol. 49, Pt. 3, pp. 179-278, 1924. As the order is thus often considerably different from that followed in Suter's *Manual*, a page reference is given wherever possible to Suter's description of the species dealt with. Full references and synonymy have, however, in no case been given, as these are in general easily obtained by looking up the single (and most important) reference placed opposite the species name.

As Suter's *Manual* embodies all records previously made, I have taken it as the standard of reference for Chatham Island shells, but I have usually mentioned his records only when the species has not occurred in the collections seen by me.

These collections are from several sources, and comprise shells (a) sent to me by friends from the Chathams, (b) beach shells collected by Messrs. Young, Allan, Marwick, and Martin, members of

the present expedition, (c) taken from rock-pools, and stomachs of cod, by Messrs. Young and Allan (for a list of the latter, see summary at end), (d) in the Otago University Museum, presented by Miss Shand. Although I have thus had much available material, it is unfortunate that so little of it was fresh, the great majority of specimens being badly beach-worn. This has made the work considerably more difficult and liable to error, and has prevented satisfactory identification in several cases. Many more new species could have been described, but it was thought safer to await better material; those here described are mostly the more prominent and characteristic forms. The Chatham minutiae, especially, are quite incompletely known, very little shell-sand being sent to me for sieving. Thus, though the present list is fairly complete as regards the beach shells, and sufficiently emphasises the main features of the fauna, it is still very incomplete, and dredging would add abundantly to the number of small forms recorded.

In this list, all group-names are treated equally as full genera; this is by far the handiest method for future reference, saves much space, and is no inconvenience to those likely to consult the list. Those who prefer to observe the sub-generic and sectional proprieties may reclassify the groups as they wish. Many of the generic names used will be unfamiliar, but a full reference has always been given, and nearly all will be found in two papers by Iredale (1915 and 1924), and one by Finlay (1926) (see bibliography at the end).

To save space, the following contractions have been used throughout this paper:—

T.N.Z.I.—*Transactions of the New Zealand Institute.*
P.L.S.N.S.W.—*Proceedings of the Linnean Society of New South Wales.*
P.R.S.Tas.—*Proceedings of the Royal Society of Tasmania.*
P.M.S.—*Proceedings of the Malacological Society (London).*
P.Z.S.—*Proceedings of the Zoological Society (London).*

Types of all new species described, and specimens of all the forms reported on are preserved in my own collection.

Note.—All new names published in my "Further Commentary on New Zealand Molluscan Systematics," and all references to this paper, should be dated 1926. I have several times referred to these in that paper itself as "Finlay, 1927," under the impression that it would not appear till that year, and Marwick in the "Veneridae of New Zealand" has done likewise, but the paper was first issued on December 23rd, 1926, and all novelties in it should bear this date. But the new names in the "Additions to the Recent Molluscan Fauna of New Zealand—No. 2," and in the "New Specific Names for Austral Mollusca," also published in *T.N.Z.I.*, vol. 57, did really, on the other hand, appear in 1927.

Class CEPHALOPODA.
Order DIBRANCHIATA.
Family SPIRULIDAE.

Spirula Lamarck, 1799; *Mem. Soc. H.N., Paris*, p. 80.

Spirula spirula (Linné, 1758). Suter, 1913, p. 1047.
5 specimens.

Family Argonautidae.

Argonauta Linné, 1758; *Syst. Nat.*, ed. 10, p. 708.

Argonauta argo Linné, 1758. Suter, 1913, p. 1066.

2 broken specimens. This species is not recorded from Australia, but Iredale has found it at the Kermadecs (*P.M.S.*, vol. 9, p. 72, 1910). It is possible that our forms would be better referred to the variety *pacifica* Dall, 1869 (*Amer. Nat.*, vol. 3 p. 237), characterised by compressed shell and pronounced auricles.

Class AMPHINEURA.
Order LORICATA.

As I understand that Mr. W. R. B. Oliver, of the Dominion Museum, is examining "Chitons" from the Chathams, and as the material forwarded to me was very scanty, I make no remarks on this group. Suter (1913) records nine species from this locality; Iredale (1915) has shown that two of these, *Acanthopleura granulata* Gm. and *Onithochiton semisculptus* Pilsb. should be rejected, and that the names of the others mostly require amendment, so that the list of Loricates recorded from the Chathams at present stands as follows:—

Plaxiphora (*Maorichiton*) *coelata* (Reeve, 1847)
Plaxiphora (*Maorichiton*) *schauinslandi* Thiele, 1909.
Loboplax violaceus (Q. and G., 1835). (Iredale, in *P.M.S.*, vol. 12, p. 101, 1916, has stated that "*Macandrellus* may fall as an absolute synonym of "*Notoplax*," and in *P.L.S., N.S.W.*, vol. 49, pt. 3, p. 214, 1924, uses *Notoplax*. Ashby (*P.M.S.*, vol. 17, p. 16. 1926) uses *Notoplax*, subgenus *Loboplax* Pilsbry, proposed for this species.
Ischnochiton maorianus Iredale, 1914.
Sypharochiton pellisserpentis (Q. and G., 1835).
Sypharochiton sinclairi (Gray, 1843).
Onithochiton neglectus Rochebrune, 1881.

Class GASTEROPODA.
Order DIOTOCARDIA.
Family Scissurellidae (*vide* Iredale, 1924, p. 215).

Scissurella D'Orbigny, 1823; *Mem. Soc. H.N., Paris*, p. 340.

Scissurella, n. sp.

No true *Scissurella* has yet been reported from any of the provinces of the Maorian Sub-region, but an undescribed species has been known to me for some time from Dunedin Harbour (3 to 60 fathoms), and as a fossil, in the Castlecliff beds. It is related to *S. ornata* May (*P.R.S. Tas. for 1908*, p. 57; Pl. 6, Figs. 4, 5) but has fewer ribs. A second new species from New Zealand is represented by a single specimen picked off a hydrazoan from the Chathams; it differs in having still more ribs than *ornata*, and the fasciole not on the periphery but half-way between it and the suture, the spire is not so flat as in the Mainland form, and the body-whorl more convex. It would, however, be unsafe to describe a species of this genus from a unique example.

Sinezona Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 341.

Sinezona subantarctica var.

Hedley (*Austr. Antarct. Exped.*, vol. 4, pt. 1, *Mollusca*, p. 36, 1916) described *Schismope subantarctica* nov. from a single specimen from a worm tube collected on Macquarie Is. From the Lyall Bay *S. brevis* Hedley and the Otago Peninsula *S. laevigata* Iredale, this differs in obsolence of sculpture; a single specimen from the Chathams generally agrees with Hedley's species, but the sculpture is slightly stronger and there is a slight fasciole behind the perforation which slightly angles the body-whorl. Miss Mestayer (*T.N.Z.I.*, vol. 51, p. 130, 1919) has reported *S. sub-antarctica* from Lyall Bay and 50 fathoms off the Snares; the Snares species is certainly different, while the Lyall Bay form may be the same as the Chatham shell, which I prefer not to describe from one specimen.

Family FISSURELLIDAE.

Tugali Gray, 1843; *Dieff. N.Z.*, vol 2, p. 240.

Tugali suteri (Thiele, 1916). Finlay, 1926, p. 344.

Common; described from the Chathams, and restricted to that region, the related mainland form being subsp. *bascauda* Hedley.

Tugali cf. **elegans** Gray, 1843. Finlay, 1926, p. 344.

One much worn specimen, obviously different from *suteri*, has a trifid sinus-rib and so belongs to the *elegans-parmophoidea* group, but is too damaged to determine accurately. The Oligocene *T. aranea* Marwick (*T.N.Z.I.* vol. 58, p. 474, 1928) from Pitt Island, may be allied.

Montfortula Iredale, 1915; *T.N.Z.I.*, vol. 47, p. 433.

Montfortula chathamensis n. sp. (Figs. 34, 35.)

Shell very similar to *M. conoidea* (Reeve), but less elongate and relatively higher, oblong rather than oval in shape. Ribs less unequal, all rather coarse, the quadruple arrangement of *conoidea* being much less marked. Apex decidedly nearer the front, the anterior slope being almost straight instead of convex. For the name *conoidea* (Reeve) for the common Peronian Australian shell, *vice Hemitoma aspera* (Gould), see Iredale, 1924, p. 216.

Length, 13.5 mm., width, 10 5 mm.; height, 6.5. mm.

Corresponding dimensions for *conoidea*:—13.5; 9.5; 5.5.

Three specimens, the holotype well preserved.

Emarginula Lamarck, 1801; *Syst. An. s. vert.*, p. 69.

Emarginula striatula valentior n. subsp. (Figs. 56, 57.)

Differing from the species in far more robust habit; shell higher and thicker, sculpture coarser; the growth tendency is to produce a shorter shell, more spread out fanwise posteriorly, and less regularly elongated; the apex thus tends to become more centralised and is notably higher. The type of *striatula* Q. and G. was a dredged northern shell, and these, as Suter remarks, are always fragile and thin, small, and with delicate sculpture; he also notes, "the largest specimens I have seen are from the Chatham Islands, and they are fairly solid" (1913, p. 100). The littoral shells are always coarser

in build than the dredged ones, but, apart from this, Chatham and South Is. shells seem to be higher and less elongate than their northern relatives, and it is for them that I form the new subspecies; deep water southern shells may require further separation later.

Length, 21 mm.; width, 15.5 mm.; height, 12 mm.

Corresponding dimensions of an Auckland beach shell here figured (Fig. 58) as the northern expression of *striatula,* 16.5: 11: 6.5.

4 beach-worn, but well preserved shells from the Chathams (including the holotype), and numerous specimens from South Is. beaches.

Two Oligocene forms of the *striatula* type have been described by Marwick (1928, pp. 473, 474) as *E. pittensis* and *galeriformis.*

Incisura Hedley, 1904; *Rec. Austr. Mus.* vol. 5, p. 91.

Incisura lytteltonensis (Smith, 1894). Suter, 1913, p. 98.
One specimen.

Monodilepas Finlay, 1926; *T.N.Z.I.,* vol. 57, p. 343.

Monodilepas skinneri n. sp. (Fig. 59.)

Quite distinct from *monilifera* (Hutt.) in elongated, subrectangular shape, rather crass test, and different sculpture. Sides parallel, ends regularly and subequally rounded; in *monilfera* the sides rather rapidly converge, owing to the marked widening of the shell behind, and attenuation in front. Shell quite solid, interior margin flatly bevelled off. Radial ribs coarse and somewhat indistinct, interstices generally much narrower; distinct reticulation present only just below foramen, elsewhere the concentric ribs are mainly rough corrugations on shell: *monilifera* has distinct thread-like radials (with much wider interspaces) strongly reticulated all over by raised sharp threadlets, concave outwards, distributed discontinuously between the radials. Interior foramen-callus rectangularly oval in shape; a little pointed anteriorly, but otherwise not triangular as in *monilfera.* Keyhole shape of foramen very pronounced from all aspects. Animal much too wide and long for shell.

Length, 21.5 mm.; width, 14 mm.; height, 5 mm.

One animal, with the shell attached, from a fish's stomach, almost fresh. Named after Mr. H. D. Skinner, archaeologist and leader of the Expedition.

Family HALIOTIDAE.

Haliotis Linné, 1758; *Syst. Nat.,* ed. 10, p. 779.

Haliotis iris Martyn, 1784. Suter, 1913, p. 94.
Haliotis australis Gmelin, 1791. *Id.,* p. 93.
Haliotis virginea Gmelin, 1791. *Id.,* p. 95.

All common, especially *australis*; young shells very plentiful. Hopkinson (*P.Z.S.,* 1907, p. 1035) has shown that the correct date of Gmelin's work is 1791, not 1790, as Suter has written throughout the *Manual.*

Family TROCHIDAE.

Coelotrochus Fischer, 1880; *Coq. Viv.*, p. 417.

Coelotrochus huttoni (Cossman, 1918). Finlay, *P.M.S.*, vol. 16, pt. 2, p. 100, 1924.

Four specimens, agreeing absolutely with Otago Heads shells and Castlecliff fossils. I have seen no *tiaratus* (Q. and G.) in the collections sent to me from the Chathams.

Thorista Iredale, 1915; *T.N.Z.I.*, vol 47, p. 436.

Thorista viridis (Gmelin, 1791). Suter, 1913, p. 110.
Common.

Thoristella Iredale, 1915; *T.N.Z.I.*, vol. 47, p. 436.

Thoristella chathamensis (Hutton, 1873). Suter, 1913, p. 107; Finlay, 1926, p. 350.

Common. When Hutton described this species (*Cat. Mar. Moll.*, p. 36), he recorded it from "Chatham Islands only": this is much nearer the truth than the distribution given in the *Manual*, which has already been commented on by Iredale (1915, p. 436). The only other locality from which I have seen specimens that could be reasonably referred to *chathamensis* is Stewart Is. As Suter's diagnosis is a composite one, and Hutton's is sketchy, I present a new description of the essential features:—

Shell wide, not high; base flat. A strong basal keel projects as a rim just above suture on spire-whorls; 7 equal flat spiral cords per whorl, interstices linear. Axials may be quite obsolete, or restricted to coarse crenulations of the infrasutural cord; when fully developed there are about 20 elongated nodular swellings on body-whorl, reaching from suture half-way over whorl, and about 14 low undulations on peripheral keel. Colour-pattern striking, dark-brown or sienna zigzag stripes and dots on an almost white background; the dull green of *oppressa* and *dunedinensis* absent. For some further details, see comparison with *fossilis* Finlay (1927, p. 350).

T. oppressa (Hutton) is recorded by Suter from the Chathams, but is unlikely to occur there, and may be rejected.

Melagraphia Gray, 1847; *P.Z.S.* (*Lond.*), p. 145.

Melagraphia aethiops (Gmelin, 1791). Suter, 1913, p. 116.
Common.

Zediloma Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 352.

Zediloma arida Finlay, 1926 (*coracina* auct., not of Philippi).

See Suter, 1913, p. 114 (as *coracina*), and Finlay, *l.c.*, p. 353. Juvenile shells very common.

Suter has also recorded three other Monodonts from the Chathams, viz., *Zediloma digna* Finlay (as *M. nigerrima*, but not of Gmelin), *Z.* (*Fractarmilla*) *morio* (Philippi), and *Cavodiloma coracina* (Philippi) (as *M. excavata* Ad. and Ang.), but I have seen no specimens of these. For these genera and name-changes, see Finlay, 1926.

Cantharidus Montfort, 1810; *Syst. Conch.*, vol. 2, p. 251.

Cantharidus opalus (Martyn, 1784). Suter, 1913, p. 124.

There seem to be two forms of this shell; one tall and rather narrow, with contracted base, narrow aperture, and straight or but very slightly concave sides; the other squat and wide, with very wide base, large aperture, and strongly-concave sides. The latter form is the only one I have seen from the Chathams, but I have only four adult specimens; juveniles, though very plentiful, cannot be grouped with certainty. The tall form seems to predominate on the mainland, but as I have a squat specimen amongst others from Stewart Is., and another from the North Is., I hesitate to separate these groups definitely till more material indicates the wisdom or error of so doing. It is difficult to state what Suter's record (1913, p. 131) of *Thalotia conica* (Gray) is based on; it must, of course, be rejected.

Micrelenchus Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 355.

Micrelenchus sanguineus (Gray, 1843). Suter, 1913, p. 128.

Micrelenchus tenebrosus (A.Ad., 1853). Suter, 1913, p. 129.

Micrelenchus tenebrosus huttoni (Smith, 1876). Suter, 1913, p. 129.

Micrelenchus dilatatus (Sow., 1870). Suter, 1913, p. 123.

Four examples of the first, one of each of the next two, the last very common. Marwick (*T.N.Z.I.*, vol. 58, p. 475, 1928) has reported *M. rufozona* (A.Ad.) from the Pliocene of Titirangi, but the specimens differ in base, pillar, and growth habit from this North Cookian form, and are nearer *sanguineus*, but have a rounder periphery and more expanded aperture; probably a new species should be erected.

Family TALOPHIDAE nov.

This seems to be needed for the various Minolioid genera such as *Talopia* Gray, 1842, *Minolia* A.Ad, 1860, *Talopena* Iredale, 1918, *Spectamen* Iredale, 1924, *Antisolarium, Conominolia, Zeminolia,* and *Zetela,* all of Finlay, 1926, but not *Ethminolia* Iredale, 1924; of these *Talopia* is the oldest name, and may be taken as the foundation of the Family. *Solariella* Wood, 1842, and *Machaeroplax* Friele, 1877, perhaps belong here, but, being northern groups, may be more closely related to other associations. Thiele has placed these in his subfamily Margaritinae, but Iredale has noted (*Rec. Austr. Mus.*, vol. 14, No. 4, p. 258, 1925) that, as far as Austral species are concerned, this should be termed Stomatellinae, and to the *Euchelus-Stomatella* series the Austral Minolioids show little resemblance.

Antisolarium Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 359.

Antisolarium egenum (Gould, 1849). Suter, 1913, p. 141.

Several specimens.

Family CALLIOSTOMIDAE.

Maurea Oliver, 1926; *Proc. Mal. Soc.*, vol. 17, p. 108.

Maurea tigris (Martyn, 1784). Suter, 1913, p. 148.

3 shells. I can observe no differences in Cookian, Forsterian, and Moriorian specimens.

Maurea cunninghami pagoda (Oliver, 1926). *Proc. Mal. Soc.*, vol. 17, p. 112; also Finlay, *T.N.Z.I.*, vol. 57, p. 485 (as *cunninghami regifica*).

2 typical specimens. The only Tertiary *Maurea* from the Chathams (*finlayi* Marwick; 1928, p. 476) is not related to these two species.

Mucrinops Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 360.

Mucrinops punctulata (Martyn, 1784). Suter, 1913, p. 146.

2 specimens; curiously enough they belong to the typical Cookian form, and not to the Forsterian var. *urbanior*. It is quite possible that the two forms represent stational rather than regional variants, but this may be elucidated later.

Suter's record, following Pilsbry, of *M. spectabile* (A.Ad.) from the Chathams is probably based on an aberrant *punctulatum*.

Family STOMATELLIDAE. (*vide* Finlay, 1926, p. 371.)

Herpetopoma Pilsbry, 1890; *Man. Conch.* (1), vol. 11, p. 430.

Herpetopoma bella (Hutton, 1873). Suter, 1913, p. 149.

Common; type comes from the Chathams; recorded otherwise only from the Cookian region.

Margarella Thiele.

Margarella fulminata (Hutton, 1873). Finlay, 1926, p. 357.

Very abundant, restricted to the Moriorian province, and one of its most characteristic shells. Marwick *T.N.Z.I.*, vol., 58, p. 475, 1928 describes a *Margarella runcinata* from Oligocene beds at Waitangi, but compares it with *decepta* Iredale rather than with *fulminata*; it is imperforate.

Family UMBONIIDAE.

Zethalia Finlay, 1926; *T.N.Z.I.*, vol 57, p. 369.

Zethalia zelandica (A.Ad., 1854). Suter, 1913, p. 171.

3 specimens. Also found in the Pliocene at Titirangi.

Family LIOTIIDAE.

Liotella Iredale, 1915; *T.N.Z.I.*, vol. 47, p. 442.

Liotella n. sp. aff. *polypleura* (Hedley, 1904).

A single specimen, not worth description at present, is closely related to *polypleura*, but has many more axial ribs, and the interstices appear to be striate.

Family TURBINIDAE.

Modelia Gray, 1840 (?).

Modelia granosa (Martyn, 1784). Suter, 1913, p. 163.

Common. Hutton named a young shell from the Chathams *Liotia* (*Arene*) *shandi* (*Cat. Mar. Moll.*, p. 35, 1873) but Moriorian specimens do not seem regionally separable from typical Cookian and and Forsterian forms.

Imperator Montfort, 1810; *Conch. Syst.*, p. 199.

Imperator heliotropium (Martyn, 1784). Suter, 1913, p. 166.

One shell, three opercula. Ancestral at the Chathams may be the Oligocene *I. anthropophagus* Marwick (*T.N.Z.I.*, vol. 58, p. 477, 1928).

Cookia Lesson, 1832; *Illust. Zool*, vol. 15.

Cookia sulcata (Martyn, 1784)). Suter, 1913, p. 167.

Not uncommon, especially young shells. These latter seem to correspond exactly to Webster's *Astralium pyramidale* (*T.N.Z.I.*, vol. 37, p. 276, 1905) which Suter places in the synonymy of the subsp. *davisii* Stowe, 1872, for which the earliest name seems to be *Risella kielmansegi* Zelebor, 1866, as I have already pointed out (1926, p. 368).

Families Acmaeidae and Patellidae.

A critical account of these, as regards the Chathams, must be left to some future investigator. Suter has recorded some twelve species of the two Families, but only three were brought to me, and only badly worn beach specimens of these, so it would be absurd to offer any critical notes. The *Acmaeas* recorded by Suter are:—*Patelloida corticata* (Hutton, 1880), *P. perplexa* (Pilsbry, 1891), *Atalacmea fragilis* (Sowerby, 1823), *Conacmea parviconoidea* (Suter, 1907), and *Radiacmea rubiginosa* (Hutton, 1873). I have seen only the latter from this locality; it is common as a dead shell, and was described from here; Oliver (*T.N.Z.I.*, vol. 56, p. 565, 1926) has restricted it to the Chathams, and notes that it is separated by its broader and more elevated shell, more central apex, and more distant ribs from the mainland *inconspicua* (Gray), which, under the synonymic name *cingulata* Hutton, is the orthotype of *Radiacmea* Iredale. *P. perplexa* (Pilsb.) should be rejected from the Neozelanic fauna, and it is very probable that the record of *corticata* is based on beach-worn *rubiginosa,* which is very variable. Marwick has described (*T.N.Z.I.*, vol. 58, p. 473, 1928) an interesting Pliocene form from Titirangi as *Atalacamea elata*; it is probably ancestral to *fragilis.*

Seven species of *Cellana* are recorded by Suter:—*antipoda* (Smith, 1874), *denticulata* (Martyn, 1784), *radians earlii* (Reeve, 1855), *r. affiinis* (Reeve, 1855), *r. flava* (Hutton, 1873), *redimiculum* (Reeve, 1854) and *strigilis* (H. and J., 1841). Iredale has given notes on these and other species (1915, pp. 430-432), rejecting *antipoda* as not of Smith, and *affinis* as preoccupied, and uniting *strigilis* and *redimiculum.* However, I have noted (1926, p. 337) that *redimiculum* may be retained for the mainland shells, *macquariensis, terroris,* and *strigilis* (= *illuminata*) being names for Rossian forms. The common Chatham limpet is of this style, and may be united *pro. tem.* with the Forsterian shells as *Nacella redimiculum* (Reeve, 1854). The only other limpet seen from the Chathams is a *Cellana* of the *radians* type, and is perhaps what Pilsbry named *Acmaea chathamensis*; it may be left under this name till a good suite of fresh specimens, can be examined.

Order MONOTOCARDIA.
Suborder TAENIOGLOSSA.
Family LITTORINIDAE.

Melarhaphe Menke, 1828; *Synop. Meth. Moll.*, p. 23.

Melarhaphe zelandiae Finlay, 1926. *T.N.Z.I.*, vol. 57, p. 375.
Common; = *mauritiana* Suter (1913, p. 188), not of Lamarck.

Malarhaphe cincta (Q. & G., 1833). Suter, 1913, p. 187.
Eight very young specimens are more regularly acuminate and less inflated than those referred to the previous species, and probably belong here.

Family BEMBICIIDAE.

Kesteven (*Rec. Austr. Mus.*, vol. 4, 1902) showed that *Risella* Gray and *Risellopsis* Kesteven were entitled to group distinction from the Littorinas, and so proposed the Family Risellidae. Hedley has merged this in the Family Littorinidae, but the aperture formation and details of anatomy seem to indicate separation from the *Melarhaphe-Tectarius* association. *Bembicium* Phil. having supplanted *Risella* Gray, the family name therefore becomes *Bembiciidae*

Risellopsis Kesteven, 1902; *Rec. Aust. Mus.*, vol. 4, No. 7, p. 319.

Risellopsis varia (Hutton, 1873). Suter, 1913, p. 191.
Common

Risellopsis varia carinata Kesteven, 1902. Suter, 1913, p. 192.
Common. It is doubtful whether it is at all useful to maintain a separate name for the carinate form; as there are all gradations at every locality, the one never occurring without the other. It might be interesting to study the relative abundance of the two forms at different localities.

Family RISSOIDAE.

Haurakia Iredale, 1915; *T.N.Z.I.*, vol. 47, p. 449.

Haurakia hamiltoni (Suter, 1898). Suter, 1913, p. 200.
One specimen. This is typically a Cookian species, but Iredale (*T.N.Z.I.*, vol. 40, p. 393, 1908) has recorded it as found alive in seaweed-washings at Banks Peninsula.

Merelina Iredale, 1915; *l.c.*, p. 449.

Merelina plaga Finlay, 1926. *T.N.Z.I.*, vol. 57, p. 378.
4 specimens, differing at sight from the Lyall Bay *lyalliana* Suter but agreeing well with Snares Is. shells. Marwick (*T.N.Z.I.*, vol. 58, p. 478, 1928) compares his *M. avita* (Oligocene, Pitt Island) with *lyalliana* rather than with *plaga*.

Subonoba Iredale., 1915; *l.c.*, p. 450.

The forms of this genus, as also many species of *Esta*, *Notosetia*, and *Dardanula*, cannot be satisfactorily determined until the Suter types are available for study. There are so many new species of them all, and Suter's descriptions are so inadequate and his figures so wretched, that it is an impossibility to identify most of the

forms at present. Of *Subonoba* I have three species from the Chathams, *S.* cf. *fumata* (Suter), *S.* cf. *insculpta* (Murdoch), and *S.* n. sp.; 6 specimens of the second, one of the first and last. The new species is badly worn and not worth description.

Estea Iredale, 1915; *l.c.*, p. 451.

Estea n. sp. aff. **zosterophila** (Webster, 1905).

For reasons just stated I do not describe this, though it is plentiful at the Chathams and in the Forsterian province. It is the southern analogue of the Cookian *zosterophila,* being much larger and more solid.

Estea minor (Suter, 1898). Suter, 1913, p. 211.

Common. I have already stated (*T.N.Z.I.*, vol. 55, p. 487, 1924) that this is a distinct species from *zosterophila.*

Estea n. sp. aff. **minor.**

Not uncommon; larger and wider than *minor,* with a still more capacious aperture.

Estea sp. cf. **subfusca** (Hutton, 1873).

One worn specimen, with the upper part of the spire lost, but evidently with a very high spire, and a small aperture.

The two Pliocene species described by Marwick (*T.N.Z.I.*, vol. 58, p. 478, 1928) as *E. insulana* and *E. subtilicosta* do not seem to be related to the Recent forms.

Austronoba Powell, 1927; *T.N.Z.I.*, vol. 57, p. 541.

Austronoba martini n. sp. (Figs. 12, 13.)

Close to *A. carnosa* (Webster, 1905), but somewhat stronger in build, rather wider, spire relatively shorter, the whorls less convex and the sutures consequently shallower. 12-14 very indistinct axials per whorl on early whorls alone, absent on last two whorls; spirals distinct, especially on lower whorls, about 30 on body-whorl, about 14 on penultimate. Spire 1½ times height of aperture, which is as in *carnosa,* but the peristome is less incomplete, rather thicker, and less effuse below. Colour, sienna or mauve-brown, a narrow white band along the middle of the whorls, and sometimes a second on base; the shells are all beach-worn, so the colour when fresh is probably darker.

Height, 2.7 mm.; diameter, 1 mm.

10 specimens. *Austronoba* does not seem to have been previously reported south of the Cookian Province; it is thus very interesting to find it at the Chathams, as it must have come there from the north. Oliver (*T.N.Z.I.*, vol. 47, p. 519, 1915) has recorded both *Onoba carnosa* and *O. candidissima* (Webster) from the Kermadec Province; I have not seen the latter, but Kermadec specimens of the former evidently represent a new species, being smaller with markedly convex and frequently angled whorls, and strong persistent axials, etc.*

---

*Since this was written, Powell has described both these as new species, *Austronoba oliveri* and *A. kermadecensis* respectively (*T.N.Z.I.*, vol., 57, p. 542).

Rissoina D'Orbigny. 1840; *Voy. Amer. Mer.*, p. 52.

Rissoina chathamensis (Hutton, 1873). Suter, 1913, p. 220.

Very common, but mostly worn; described from here. Marwick (1928, p. 479) has referred a single Oligocene specimen to this species.

Dardanula Iredale, 1915; *T.N.Z.I.*, vol. 47, p. 452.

Dardanula olivacea (Hutton, 1882). Suter, 1913, p. 225.

Common. The Chatham specimens are divisible into three groups, probably of specific value, but elaboration of this difficult genus must be left for a future occasion.

Family HYDROBIIDAE.

Potamopyrgus Stimpson, 1865; *Am. Journ. Conch.*, vol. 1, p. 53.

Potamopyrgus antipodum zelandiae (Gray, 1843). Suter, 1913, p.. 231.

Not uncommon.

Potamopyrgus badia (Gould, 1848). Suter, 1913, p. 231.

3 specimens. Suter reports *P. corolla* (Gould, 1847) as the only Chatham species, but the three angled and spinous shells I have seen from there are far better referable to *badia* than to *corolla.*

Family CALYPTRAEIDAE.

Zegalerus Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 392.

Zegalerus crater Finlay, 1926, *l.c.*

2 specimens; they are the only Recent specimens I have seen, and I cannot separate them from typical Nukumaruian fossils; both are beach-worn. The species is common in the Pliocene sands at Titirangi (Marwick; *T.N.Z.I.*, vol. 58, p. 480, 1928).

Sigapatella Lesson, 1830; *Zool. Coquille*, vol. 2, p. 389.

Sigapatella novae zelandiae Lesson, 1830. Suter, 1913, p. 285 (as *maculata* Q. and G).

Common.

Family CERITHIIDAE.

Zeacumantus Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 380.

Zeacumantus subcarinatus (Sowerby, 1855). Suter, 1913, p. 239.

Common; includes *tricarinata* (Hutton, 1883), also reported by Suter, but not a distinct form.

Lyroseila n. gen. Type: *Seila chathamensis* Suter, 1908.

Lyroseila chathamensis (Suter, 1908). Suter, 1913, p. 252.

Examination of perfect apices of this species has shown that it cannot be referred to *Hebeseila* Finlay, as I tentatively placed it (*T.N.Z.I.*, vol. 57, pp. 382, 385, 1926), but constitutes a distinct group. The embyro is of three whorls, the first smooth, depressed, and consisting of a blunt, almost Caricelloid point, rapidly developing a median keel and passing into the strongly sculptured next two

whorls; these have, as Suter states (only he considered them as shell-whorls, the protoconch being "of one smooth whorl only"), "2 cinguli, the upper of which is inconspicuous, but the lower one is thick and prominent"; the cinguli pass into the shell proper rather imperceptibly, without any varix, the change being marked only by the bifurcation of the lower rib, so that the following whorls bear three subequal spirals; the whole embryo is slightly wider than the succeeding whorl, so that it interrupts the straight outlines of the spire, and projects as a bluntly-pointed cylinder. This apex differs radically from those of *bulbosa* Suter, and *terebelloides* Hutton, the genotypes of *Hebeseila* and *Notoseila* respectively, and the species itself has a Pliocene ancestor in *S. huttoni* Suter (*N.Z.G.S. Pal. Bull, No. 2*, p. 16, 1915). This differs only in its more convex whorls and deeper sutures, the embryo being exactly the same; no pre-Pliocene member of the group is yet known.

Re-examination of more abundant material does not enable me to separate Recent Cookian and Moriorian specimens of *chathamensis* (I have seen no Forsterian examples, though the type is from Foveaux St.), so I still feel that Suter's *cochleata* (1913, p. 252) should be reduced to a synonym.

Iredale (1915, p. 455) has noted that the specific name *terebelloides* must be credited to Hutton rather than von Martens. He quotes Suter's statement that "Hutton's name has priority by one month," which is not quite correct, the preface to the *Cat. Mar. Moll. N.Z.* being dated May 7th, while that to the *Crit. List.* bears the date October 25th, so that there is more than five months' clear priority. Now Hutton merely reproduces von Martens' description, giving no locality, but saying: "This is the same as my *Cerithium cinctum*" (the type of which, from Stewart Is., is in the Dominion Museum, Wellington). Von Martens in his account merely states that the specimens were sent by Dr. von Muller "with the statement that they came from New Zealand." Now I cannot at present separate northern and southern specimens of *terebelloides*, but it is desirable that a type specimen and locality should be fixed for every species as far as possible. I therefore here nominate Stewart Is. as type locality, and select the type of *C. cinctum* Hutton, 1873, as neotype of *Notoseila terebelloides* (Hutton, 1873).

Family TURRITELLIDAE.

Maoricolpus Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 389.

Maoricolpus roseus (Q. & G., 1834). Suter, 1913, p. 270.
8 examples.

Family LIPPISTIDAE.

This, as Iredale has indicated (1924, p. 251), replaces Family Trichotropidae.

Trichosirius Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 395.

Trichosirius inornatus chathamensis n. subsp. (Fig. 40.)

Differs from typical shells in being more squat, with more prominent peripheral and basal carinae, the four peripheral spirals

being notably coarser and stronger, the radials also coarser, and the shoulder much less steeply inclined.

Height, 11 mm.; diameter, 8 mm.

7 specimens.

I have further new species of this genus from southern waters, but have seen nothing quite like these Chatham shells.

Family VERMETIDAE.

Vermicularia Lamarck, 1799; *Mem. Soc. H.N. Paris,* p. 78.

Vermicularia sipho (Lamarck, 1818). Suter, 1913, p. 259.

Novastoa Finlay, 1926; *T.N.Z.I.,* vol. 57, p. 386.

Novastoa zelandica (Q. & G., 1834). Suter, 1913, p. 260.

Synonym: *Siphonium lamellosum* Hutton, 1873. Suter, p. 261.

Several masses of irregular shape. One agglomerate consists of some half-dozen specimens having the first few whorls spirally coiled up, the remainder vermiform, more or less irregularly twisted in a moderately straight line; i.e., the shell is identical in growth with Q. and G.'s *Vermetus zelandicus,* though in all other respects it is a typical example of *lamellosum* Hutt. The only diagnostic difference between the two is the presence in the latter species of an operculum, and I think it unsafe to rely solely on this. Suter, following Hutton's original description states that the operculum of *lamellosum* is hemispherical; I cannot understand this, unless Hutton mistook a loose septum for the operculum. Internal septa are very infrequent, they are concave distally, becoming gradually confluent with the walls of the tube anteriorly; longitudinal internal ridges are absent. Operculum shaped, like an everted mushroom; the exterior lightly concave, with a prominent, thickened, and slightly raised inner calcareous disc, surrounded by a wider, outer, quite solid, horny rim; interior with a stalk-like cylindrical, dome-topped pillar, merging in to the calcareous disc, which is coated on the inside with chitin and marked off from the horny rim by a deep circular furrow. The usual beach specimens of *lamellosum* are much worn, and consist of agglomerates of only the early whorls, only occasionally are they found developing long tubes as in the typical *zelandica* form.

Apart from its occurrence at the Chathams, where it seems commoner than elsewhere, this species is apparently purely Cookian in range. It is significant that Suter has recorded *lamellosum* from the Bay of Islands, whence also come the type of *zelandica.*

Magilina Velain, 1877; *Arch. Zool. Exper.,* vol. 6, p. 106.

Magilina sp., probably new.

A single specimen of a vermetid that cannot be referred to any species at present recorded from New Zealand. It is evidently very close to ***M. caperata*** (Tate and May, 1900) from Tasmania and New South Wales, but I have no actual specimens for comparison. The specimen is too much worn and broken for description, but forms an interesting record as the genus is new to New Zealand.

Siliquaria Bruguière, 1789; *Encycl. Meth.*, vers. 1, p. 15.

Siliquaria weldii Ten.-Woods, 1876. Suter, 1913, p. 264.
One shell.

Family Janthindae.

Janthina Bolten, 1798; *Mus. Bolt.*, p. 75.

Janthina violacea Bolten, 1798. Oliver, 1915, p. 525.
Two small shells.

Janthina exigua Lamarck, 1822. Suter, 1913, p. 299.
7 juvenile shells.

Family Scalidae. (*vide* Finlay, 1926, p. 401).

Cirsotrema Mörch, 1852; *Cat. Yoldi*, p. 48.

Cirsotrema zelebori (Dunker, 1866). Suter, 1913, p. 322.

Suter has reported this from the Chathams; I have seen no specimens, but it is certain to occur there. A closely related Oligocene species, *C. chathamensis* has been described by Marwick from Momoe-a-atoa (*T.N.Z.I.* vol. 58, p. 483, 1928).

Family Cymatiidae.

Charonia Gistel, 1848; *Naturg. Thier*, p. 170.

Charonia capax Finlay, 1926. *T.N.Z.I.*, vol. 57, p. 397.

This also is not autoptically known to me from this locality, though Suter has recorded it (as *rubicunda* Perry).

Cymatium Bolten, 1798; *Mus. Bolten*, p. 129.

Cymatium spengleri (Perry, 1811). Suter, 1913, p. 308.
Two shells.

Gondwanula Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 399.

Gondwanula tumida (Dunker, 1862). Suter, 1913, p. 309.
4 specimens.

Xenogalea Iredale, 1927; *Rec. Austr. Mus.*, vol. 15, No. 5, p. 339.

Xenogalea collactea, n. sp.

Phalium n. sp. (*labiatum* auct.); Finlay, *T.N.Z.I.*, vol. 57; Pl. 20, Figs. 62, 63; 1926.

Shells of the labiata type (i.e., almost smooth, especially on spire and base, with small and partly closed umbilical opening, and with denticles, not faint furrows, on lower part of outer lip), fairly wide, spire rather short. Colour, pale brownish-grey with lilac tinges, mottled with darker shades of the same, 3-6 narrow indistinct bands of variously-shaped brown spots with white centres, defined on outer lip as four double bands of dark brown, the lowest at canal, outer and inner lips otherwise white. Spiral sculpture absent except on initial whorls, and sometimes a few grooves on base. No shoulder present till last whorl, which develops 5-7 rather coarse nodules extended into very indistinct and irregular low axial plications.

Several oblique raised ridges at inner base of parietal callus, directed forwards.

Height, 69 mm.; diameter, 48 mm.

Holotype and two other specimens from Opotiki, Bay of Plenty.

Xenogalea powelli n. sp.

Phalium n. sp. (*pyrum* auct.); Finlay, *T.N.Z.I.*, vol. 57; Pl. 20, Fig. 64; 1926.

A Cookian deeper water representative of the *pyrum* series. Very similar to *X. finlayi* Iredale, but with a short spire and traces of nodulation on the shoulder. Colour less tawny, more olive in shade; shell less inflated, especially basally.

Height, 73 mm.; diameter, 52 mm.

Holotype from off Whakatane, Bay of Plenty, in 40-50 fathoms; several other specimens from the same locality collected by Mr. A. W. B. Powell, in compliment to whom the species is named.

This is the form erroneously united with *X. finlayi* Iredale (*C. stadialis* Finlay, *non* Hedley; *T.N.Z.I.*, vol. 55, p. 526, 1924); examination of further material shows that the northern and southern shells are distinct.

These two forms were indicated as new species in the paper referred to, but not named, as Iredale's account of the Australian Cassids had not then appeared. Only one New Zealand species (*X. finlayi* n. sp. for *Phalium stadialis* Finlay, *non* Hedley— a wrong determination; *Rec. Austr. Mus.*, vol. 15, p. 342) was, however, provided with a name in his account, so that the names I had previously intended to give to the two other species I figured in the "Further Commentary" are now supplied. *X. collactea* is, as Iredale notes, very close to his *X. insperata* (*l.c.*, pp. 349, 350), but differs in the much coarser and more distant nodules on the last whorl, the more inflated columellar region with a deeper notch above the lowest plait, and the presence of the oblique parietal ridges; it is easily distinguished from the true *labiata*. *X. powelli* is less likely to be confounded with an Australian form, and is only distantly related to *pyrum*.

No shells of the *labiata* type occur at the Chathams, the single specimen from there agreeing exactly with Stewart Is. specimens, which are a little different from typical *powelli*; the exact status of these forms, and the number of species that should be allowed in the Neozelanic area cannot be satisfactorily settled till a larger range of specimens than I have at present is available for examination. Mr. H. D. Skinner picked up another specimen on a Moriori site at Mairangi, near Wharekauri; it was artificially pierced, and had evidently been used for adornment. The sole Tertiary Cassid from the Chathams, *Phalium skinneri* Marwick, is unrelated to the Recent forms, and is made the type of a new group, *Kahua*, by Marwick (1928, p. 482).

Cochlis Bolten, 1798; *Mus. Bolt.*, pt. 2, p. 146.

Cochlis zelandica (Q. & G., 1832). Suter, 1913, p. 289.

A few specimens. A related Tertiary form at the Chathams is *C. pittensis* Marwick (see *T.N.Z.I.*, vol. 58, p. 481, 1928).

Uberella n. gen. Type: *Natica vitrea* Hutton.

Uberella vitrea (Hutton, 1873). Marwick, *T.N.Z.I.*, vol. 55, p. 570, 1924.

One specimen, but also reported by Suter, 1913, p. 291 (as *amphialus* Watson). This locality seems to be the northern limit of the range of this typically Forsterian and Rossian species.

I would temporarily place under this genus all the species referred by Marwick (*l.c.*) to *Euspira,* though the assemblage is not homogeneous, *vitrea* and *pseudovitrea* (Finlay) disagreeing with *lateapertus* Marwick, and this again with *fyfei* Marwick. Marwick, following Dall, has used *Euspira* Agassiz, 1842, instead of *Lunatia* Gray, 1847, but both these writers seem to have overlooked the investigation of this question by Harris in 1897, where a totally different result is arrived at. Dall's opinion (quoted by Marwick, that *Euspira,* introduced by Agassiz in 1842, and typified by *N. labellata* Lamk., should displace *Lunatia* Gray, 1847, typified by *Natica ampullaria* Lamk.), was announced earlier than given by Marwick, viz., in *Bull. Mus. Comp. Zool.*, vol. 43, No. 6, p. 334, 1908; but at that place no type was selected, it being merely mentioned that the first species was *N. glaucinoides* Sow. = *N. labellata* Lk. At the reference given by Marwick (*U.S. Geol. Surv., Prof. Pap., 59*, p. 87, 1909) this is definitely given as the type of *Euspira.* Harris, however, had a dozen years earlier (*Cat. Tert. Moll. B.M.*, Pt. 1, p. 264, 1897) nominated *A. sigaretina* Lk. as the type, and this must displace Dall's selection; moreover, Harris showed that the date of introduction of *Euspira* was 1837 (*Sow. Min. Conch. Grossbr.*, pp. 14, 16), (1838, according to Sherborn; *Index Anim.* 1801-1850, pt. 10, p. 2250), and that a heterogeneous collection of species was there named in connection with it. Harris's action makes *Euspira* s. str. absolutely equivalent to *Ampullina* Bowdich, 1822 (*Elem. Conch.*, 1, p. 31; Pl. 9, f. 2, no species name). This is said to be the first Latin introduction of the latter name, which was used again two years later, in a different sense, by Blainville (*Dict. Sci. Nat.*, p. 235). Thus the name *Ampullina* can be given its usual interpretation only if it be decided that a genus can rest on an unnamed, doubtfully determinable figure (Dall in 1909, *l.c.*, suggests that it is possibly *A. depressa* Lk., *non* Sow., and adopts this as the type of the genus in place of *A. sigaretina*). It is a moot point whether *Ampullina* Bowdich should not be regarded as indeterminable, and in this case would have to be replaced by *Euspira* Desor and Agassiz—it may be noted that Sherborn does not record *Ampullina* Bowdich as a valid name, though Blainville's and Deshayes's uses are duly entered—, but whatever the conclusion in this case, it disposes of *Euspira* in connection with Austral mollusca, as we have no *Ampullines.* There are many recognisable groups of *Uber* (Hedley has noted that at least three may be allowed for tropical Queensland forms, *Uber* s. str., *Mamilla* Schumacher, and *Mamillaria* Swainson, of which *Naticina* Guilding is an exact synonym), and *Lunatia* Gray—which should apparently be brought into usage again—does not seem strictly applicable to the New Zealand "Espiras." Harris, in discussing Australian Tertiary species (*l.c.*, p. 260) has included three species in *Lunatia,* but each of these represents a different group. Therefore, from consideration of

all these points, I select the best known and the most aberrant New Zealand "*Euspira*" as type of a new genus *Uberella;* it will probably be wisest to include all the other New Zealand members of the group under this name until more comparative material allows further separation to be made.

Family LAMELLARIIDAE.

Lamellaria Montagu, 1815; *Trans. Linn. Soc.,* vol. 11, p. 11.

Lamellaria ophione Gray, 1850. Suter, 1913, p. 294.

A specimen of this species in the Otago University Museum has the locality " Chatham Is." attached to it.

Family CYPRAEIDAE.

Triviella Jousseaume, 1884; *Bull. Soc. Z. Fr.,* vol. 9, p. 98.

Triviella memorata Finlay, 1926; *T.N.Z.I.,* vol., 57, p. 396.

Two specimens. Marwick (*T.N.Z.I.,* vol. 58, p. 482, 1928) compares his *T. flora* (Oligocene, Pitt. Is.) with the Mainland Pliocene *T. zelandica* Kirk rather than with *memorata.*

Suborder STENOGLOSSA.

Family OLIVIDAE.

Baryspira Fischer, 1883; *Man. de Conch.,* fasc. 6, p. 600.

Suter (1913, p. 451) has reported *B. australis* (Sow., 1830) from the Chathams, but I have seen no specimens.

Family MARGINELLIDAE.

Marginella Lamarck, 1799; *Mem. Soc. H.N.,* Paris, p. 70.

Marginella allporti (?) Ten.-Woods, 1876. Suter, 1913, p. 459.

One damaged specimen. I am not in a position to state whether this species has been rightly identified from New Zealand, but it is highly doubtful.

Suter reports only *M. pygmaea* Sow. from the Chathams; this species has not occurred to me.

Family TURRIDAE.

Phenatoma Finlay, 1924; *T.N.Z.I.,* vol. 55, p. 515.

Phenatoma novaezelandiae (Reeve, 1843). Suter, 1913, p. 477.

Phenatoma zelandica (E. A. Smith, 1877). Suter, 1913, p. 491 (as *cheesemani*).

Both these species are reported by Suter from the Chathams; I have seen neither from here, but they have a wide distribution in both main Islands.

Phenatoma decessor Marwick (*T.N.Z.I.,* vol. 58, p. 491, 1928), from the Oligocene of Pitt. Is., is noted by its author as directly ancestral to *P. novaezelandiae*; apart from this, the Tertiary Turrids at the Chathams are altogether different from those in the Recent fauna.

Guraleus Hedley, 1918; *P.L.S., N.S.W.*, vol. 51, Suppl., p. M 81.

Guraleus sp.

Suter records both *dictyota* (Hutton) and *sinclairi* (Smith). Specimens are common, though usually worn, and seem to represent but one species, but a full discussion of the generic and specific name to be used would take up much space and is reserved to appear in an account of all these forms now in preparation, where it will be more in keeping.

Zenepos n. subgen. of *Nepotilla* Hedley, 1918.
Type: *Daphnella totolirata* Suter.

Zenepos totolirata (Suter, 1908). Suter, 1913, p. 511.

One specimen; also reported by Suter; a not uncommon Forsterian form, but I doubt the Whangaroa record.

This group-name is proposed for Nepotillas more slender than the type, with numerous spiral cords rather than keels, a less exserted apex, and especially with only a slight sinus at the shoulder. *Nepotilla* s. str. has a very deep *Veprecula*-like sinus, with long parallel margins and is represented in Australia by such forms as *bathentoma* (Verco), *lamellosa* (Sow.), and *triseriata* (Verco), while in *Zenepos* may be included the New Zealand species *lacunosa* (Hutton) and probably *chariessa* (Suter), and the Australian *mimica* (Sow.) and *minuta* (Ten.-Woods).

Family BUCCINULIDAE nov.

This seems necessary to cover the Austral genera *Buccinulum* Swainson, 1837 (= *Evarne* H. & A.Ad., 1853), *Dennantia* Tate 1888, *Euthrena* Iredale, 1918, *Tasmeuthria* Iredale, 1925, *Evarnula* Finlay, 1926, and *Chathamina* nov. (*v.i.*). As a subfamily may be ranked SIPHONALIINAE nov., covering *Siphonalia* A.Ad., 1863, *Austrosipho* Cossmann, 1906, *Verconella* Iredale, 1914, *Berylsma* Iredale, 1924, *Glaphyrina* Finlay, 1926, *Aceneator* Finlay, 1926, *Pomahakia* Finlay, 1927, *Pittella* Marwick, 1928, and ELLICEA Finlay, 1928 (in Marwick, 1928), proposed for *Siphonalia orbita* Hutton, 1885 (*T.N.Z.I.*, vol. 17, p. 326); Marwick has recently (*T.N.Z.I.*, vol. 56, p. 321, 1926) referred this species and *Streptopelma henchmani* Marwick to *Streptopelma* Cossmann, judging by the resemblance of figures; this likeness is purely superficial, and actual specimens show so many differences that I doubt their inclusion in the same Family. The Family Neptuniidae covers a large suite of Boreal forms; to this, under the name Chrysodomidae, Cossmann and Suter have referred the Neozelanic forms, but it seems better to select a distinct family name for the large number of southern genera, rather similar *inter se* that centre around the New Zealand *Buccinulum*. "Euthrias" have been referred to several families, and in any case *Buccinulum* has long priority over *Euthria* Gray, 1850.

In regard to the New Zealand members, it would be out of place here to give a full account, with keys for separation of genera and species, but I have prepared this, and hope to give it elsewhere at an early date. Therefore I merely deal briefly in the present paper, with the means for separating the Chatham "*Euthrias.*"

Euthrena may be always separated from *Buccinulum* and its allies, *Chathamina* and *Evarnula,* by its protoconch, which is small, with a minute smooth portion, early weakly axially ribbed, with a conspicuous brephic stage of coarse reticulation; if this is lost or worn, the next best feature is the inner lip callus, which is vertical for less than half of its length. The three other genera have a large embryo, of several smooth whorls, showing more or less axial acceleration, but never a reticulate stage; and the inner lip callus is vertical for usually much more than half of its length. As *Chathamina* is now first proposed, a comparative diagnosis of these three groups is necessary.

Buccinulum Swainson (= *Evarne* H. & A.Ad.) :—Includes *linea* (Martyn), *pallidum* n. sp., and *sufflatum* Finlay (1926, p. 416). Axials small and numerous, confined to first three whorls.

Chathamina n. subgen. of *Buccinulum*:—Type: *Tritonidea fuscozonata* Suter, 1908. Includes also *characteristica* n. sp., and the fossil *T. compacta** and its allied new species. Generally more squat than *Buccinulum,* wider and more solid; outer lip especially very thick, and with a heavy varix just before it; axials rather stout and prominent, generally persistent over all whorls; pillar more suddenly bent; teeth of outer lip inclined to be stouter, shorter, and fewer.

Evarnula Finlay:—Includes the fossil *striata* (Hutton), a new Recent deep water species, and *marwicki* n. sp. Spire rather elate; outer lip thin and sharp, rapidly thickening internally, but without a distinct varix; axials moderately prominent and numerous, persistent up to, and often also on, last whorl; teeth of outer lip not prominent, usually only subobsolete lirae; aperture less heavily armed with denticles than in the last two groups, there being rarely more than 2-3 at inflection of canal, but the lowest always very prominent, almost as in *Dennantia*; canal much more strongly flexed to left, and with a much stronger fasciole; strong spiral sculpture predominant; whorls more medially convex and better separated than in *Buccinulum* and *Chathamina.*

Subfamily BUCCINULINAE.

Buccinulum Swainson, 1837; *Cat. Foreign Shells Man. Nat. Hist. Soc.*, p. 81.

Buccinulum lineum (Martyn, 1784). (Fig. 6.) Suter, 1913, p. 375.

Six specimens. The fact that this lives together with *pallidum* and *characteristica* is indication of the distinctness of these species, though, of course, hybrids are to be expected. *Pallidum* probably reaches its extreme northern limit here, *characteristica* is possibly restricted but may occur in the North Is. also (see below), while *linea* is typically a common Cookian species, but Forsterian stragglers are occasionally found; I have one from as far south as Taieri Beach, but I doubt its occurrence in the Rossian province.

Buccinulum pallidum n. sp. (Figs. 3, 4, 5).

Shell exactly like *B. linea* in formation of whorls and aperture, but more elate, with a taller spire, and a weakly sub-margined suture.

N.Z. Geol. Surv. Pal. Bull., No. 5, p. 35, 1917.

Colour uniformly light brownish-yellow to almost white (some worn shells show broad darker patches), the prominent purplish bands of *linea* are completely absent, bands when present being irregular and but slightly darker than rest of shell.

Height, 37 mm.; diameter, 16 mm. (type).

Holotype from Stewart Is.; 9 specimens from the Chathams; 1 specimen from Lyttelton Harbour, the type locality of *B. sufflatum* Finlay, but that species differs constantly in inflation and stronger spiral sculpture.

Chathamina new subgenus. Type: *Tritonidea fuscozonata* Suter.

Chathamina characteristica n. sp. (Figs. 29, 30, 31).

Very similar to *B. linea* in habit and style of painting, but more solid, inclined to be squat, the last whorl wide and swollen. Outer lip crass, pushed out by a broad swollen varix just behind it. Aperture tending to be heavily armed with denticles, especially on inner lip, where they are usually present over whole of its length. Canal more strongly twisted, and more flexed to left than in *linea*; this feature serves to separate immature shells of the two species, but very young specimens are not placeable with certainty.

Height, 34 mm.; diameter, 19 mm. (type). Corresponding dimensions of figured paratypes, 35 x 20 mm., and 39 x 18 mm.

This is one of the commonest and most characteristic Chatham Is. shells. I have also one specimen reputed to be from the North Is.; apart from this doubtful record, I have not yet seen it outside the Chathams.

Evarnula Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 415.

Evarnula marwicki n. sp. (Figs. 7, 8, 9).

Shell large, with strong axial and moderate spiral sculpture. Embryo as in *B. linea.* 7 shell-whorls, sub-shouldered a little above middle, slightly concave on shoulder, convex below. Suture strongly margined by a heavy cord. Spiral sculpture same style as in *striata* (Hutton), but main cords broader and secondaries weaker; 15-17 main spirals on body-whorl. Axial sculpture predominant, 13-14 axials on penultimate whorl, subobsolete on last whorl. Aperture reminiscent of *Clava,* pyriform, medially inflated, produced below into a rather long beak, twisted back and well to the left. Outer lip sharp and thin, rapidly thickened inside, but without a marked varix, tending to throw downwards and be most inflated anteriorly. Whole aperture very lightly armed, teeth on outer lip being thin and weak, more like short lirae; seldom more than 2-3 not prominent denticles at base of inner lip, and a parietal tubercle.

Height, 52 mm.; diameter, 24 mm. (type). Corresponding dimensions of figured paratype from Stewart Is., 38 x 18 mm.

The holotype and one other specimen (figured) from Warrington, near Dunedin; 5 good specimens from Stewart Is.; numerous more or less worn shells from the Chathams.

The name of Dr. Marwick, Palaeontologist to the Expedition, is attached to this species.

Euthrena Iredale, 1918; *Proc. Mal. Soc.*, vol. 13 p. 34.

Euthrena strebeli (Suter, 1908). Suter, 1913, p. 378.

Fairly common. The distinctness of this form is not beyond doubt, *vittata, littorinoides,* and *strebeli* all seem to intergrade somewhat on the mainland, and investigation of specific values in this genus must be left for another occasion. I have, however, used *strebeli* for a number of Chatham shells, evidently not *bicinctus,* of a uniformly dull colour, and very solid habit; I have identical shells from Dunedin Harbour (the type locality of *strebeli*) and other Forsterian localities. It may be noted, however, that Reeve's figure of the type of his *littorinoides* (*Conch. Icon.*, vol. 3, Pl. 12, f. 94) looks as much like *strebeli* as it does the form commonly accepted as *littorinoides.*

***Euthrena bicincta** (Hutton, 1873). *Cat. Mar. Moll.*, p. 10. (Figs. 10, 11).

Hutton rightly described this species from "Chatham Islands only." It is one of the most characteristic of the Chatham shells, and its conspicuous colour pattern renders it very striking. It seems to be restricted to the Moriorian province; occasionally a North Is. specimen turns up with much the same painting, but is always about half the size, and on comparison is easily seen to be an atypical form of *vittata,* occurring with it, though but rarely. At the size of the largest *vittata, bicincta* always has an unformed outer lip, and is evidently immature; it grows as large as *strebeli,* and has a characteristic facies which is difficult to describe. Very common at the Chathams.

Family BUCCINIDAE.

Austrofusus Kobelt, 1881; Kuster's *Conch. Cab.*, p. 127.

Austrofusus chathamensis n. sp. (Figs. 60, 61, 62, 63).

Distinguished from the typical Cookian *glans* (Bolten) by obsolescence of keels, crowded axial ribs, and especially the persistence of the latter on shoulder. 21-25 axials on penultimate whorl, strong from suture to suture on all spire-whorls, being but little thinner on shoulder, hardly nodulous on periphery, interstices 1½-2 times width of ribs, obsolete on body-whorl, being replaced by very numerous ribs of about same strength as spirals, forming a coarse but neat and even reticulation. Perpheral keel becoming almost obsolete on body-whorl, which is usually subregularly convex, lower keel absent. In *glans* there are 16-18 axials on penultimate whorl, merely indicated on shoulder, strong on lower half, prominently nodular on periphery and at lower suture, interstices 2-4 times as wide, rarely obsolete on body-whorl, and, if so, not replaced by coarse reticulation; keels very rarely obsolete, both upper and lower, and frequently a third still lower, being well defined.

Height, 54 mm.; diameter, 28 mm. (type). Corresponding dimensions of figured paratype, 59 x 33 mm.

Rather common as beach-worn shells at the Chathams; no fresh specimens seen.

This is a rather puzzling form. The characters of the Chatham shells appear constant, and they stand out at once when placed beside

North Is. specimens of *glans*. Occasionally Mainland forms are found with subobsolete keels and numerous axials, but I have seen none with ribs strongly developed on the shoulder, or with quite the aspect of *chathamensis*. In the Upper Pliocene beds at Castlecliff, however, *Austrofusus* is very common, and apparently very variable, all gradations occurring between forms with 12 distant prickly axials per whorl, and shells with twice as many cramped and blunt ribs. Some would urge that this is sufficient reason for admitting but one species, but the Recent regional forms (*glans, agrestior* Finlay* and *chathamensis* nov.) seem so well differentiated, that I prefer to regard the Castlecliff shells as in process of evolution, and would artificially separate them into three groups, *glans, chathamensis,* and some intermediate or hybrid juveniles. Oliver has treated the Kermadec Is. Cellanas somewhat similarly (*T.N.Z.I.*, vol. 47, p. 511, 1915).

Hutton also observed the different aspect presented by the Chatham shells, and referred them (*Cat. Mar. Moll.*, p. 11, 1873) to *Buccinum tritom* Lesson, 1841 (*Rev. Zool.*, p. 37). That species, however seems to be based on an old Mainland specimen, and such, as I have stated, may at first sight resemble *chathamensis*, but lack the strong shoulder ribs, etc.; it appears to be correctly treated as a synonym of *glans*,† as is also Hutton's "var. B" (*loc. cit.*). This is described as having "Body-whorl with 12 nodular transverse ribs, which do not reach to the suture; small — Cook Strait." It is possible that what I have called *glans* from Castlecliff may later deserve separation, as the tubercles and ribs are generally stouter, but this may be passed over at present.

Austrofusus glans agrestior Finlay, 1927. *T.N.Z.I.*, vol. 57, p. 486.

Of 21 specimens of *Austrofusus* from the Chatham Is., all but one were uniform in character, and referable to *chathamensis*. This one stood out at sight, having strong keels, 15 very prominent peripheral nodules per whorl, no ribs on the shoulder, sculpture nowhere obsolete, and a different shape. Though not fully grown (41 mm. x 25 mm.) it agrees exactly with the type of the Forsterian regional variety *agrestior*, and is without hesitation referred to this form.

Cominella Gray, 1850; *Fig. Moll. Anim.*, vol 4, p. 72.

Cominella maculosa (Martyn, 1784). Suter, 1913, p. 387.

Numerous specimens, the best preserved being from the stomachs of cod.

Acominia Finlay, 1926; *T.N.Z.I.*, vol. 56, p. 240.

Acominia adspersa nimia n. subsp. (Figs. 17, 18).

Differs from typical Cookian examples in larger size, more solid shell, and especially shape and elongation of last whorl. There is

**vide infra.*

†That is, if it is really Neozelanic. Suter includes it in the synonymy of *Siphonalia nodosa* (Mart.) (*Manual*, p. 368), referring to Hutton's *Cat. Mar. Moll.* of 1873, but it should be noted that in 1884 Hutton (*T.N.Z.I.*, vol. 16, p. 228, footnote) stated that the species "Inhabits Peru," and dismissed it from our fauna. There is, however, no mention made of this name in Dall's summary of the Peruvian fauna published in 1909 (*Proc. U.S. Nat. Mus.*, vol. 37, pp. 147-294).

no tendency for the spire to be short and concave and the body-whorl cylindrical, as is so often the case in Mainland specimens. Juvenile shells are not easily separable from typical *adspersa,* but as growth proceeds a characteristic aspect is developed. The spire remains prominent and wide, ½-⅔ height of aperture, and the sides are very much straighter than in *adspersa;* this is due to different shape of whorls, which are not convexly turgid, but develop a blunt subangulation at the lower suture, the long shoulder sloping almost straight at an angle of about 60; this angulation remains submedial and very prominent on the body-whorl, a feature not shown by *adspersa.* The last whorl is also much elongated, this produces a higher and larger aperture, and is especially seen in the long descending fasciole. The umbilicus is better developed.

Height, 70 mm.; diameter, 43 mm.

8 adults and several young shells.

Cominista Finlay, 1926; *T.N.Z.I.*, vol. 56, p. 240.

Cominista glandiformis (Reeve, 1847). Suter, 1913, p. 384 (as *lurida*).

5 specimens.

Eucominia Finlay, 1926; *T.N.Z.I.*, vol. 56, p. 239.

Eucominia iredalei n. sp. (Figs. 15, 16).

Shell derived from *E. nassoides* (Reeve), and with same style of sculpture, but far more massive, twice as large, and relatively almost twice as wide. The whole shell is of a squat and bulky formation, the body-whorl and aperture being especially capacious. Spire lower than aperture. Suture a little less sloping than in *nassoides.* Axial sculpture as in *nassoides,* but spirals weaker and more numerous, so that the axials are distinctly less tuberculate. Stronger sub-sinus in outer lip, but weaker denticles within. Wider fasciole. Still larger embryo.

Height, 53 mm.; diameter, 31 mm. Corresponding dimensions of figured paratype, an extreme form as regards width, 46 x 31 mm.

Chatham Islands only; 11 specimens. This is Hutton's "var. B" of *Buccinum zelandicum* Reeve (*Cat. Mar. Moll.*, p. 14, 1873). The true habitat and status of the latter species do not seem as yet to have been recognized, but it is certainly not Neozelanic, and looks like a true *Buccinum.* Suter (1913, p. 389) has stated that " This subantarctic species is very variable. The Chatham Is. specimens are generally large and more inflated, and Hutton separated them in 1873 as var. B. The *C. nodicincta* v. Mts. is most likely this variety, but shells nearly approaching it occur also in Foveaux St." I am unable to agree with this, and have not so far found it variable; if all the specimens are lumped together, there is certainly a very wide range of differences shown, but the important point is that forms from the same regional locality or depth are practically constant, and there are evidently numerous well-defined races which ought all to be recognised. Examination of Reeve's excellent figure shows that the Stewart Is. form (Fig. 14) is typical and therefore the true *nassoides*; I have similar shells from Chalky Inlet and as far north as Dunedin, so that the species is characteristically Forsterian. In deep water in the same region occurs a benthal relative, quite distinct

in habit; a second benthal form occurs north of Oamaru. Another quite distinct form occurs off the Snares Is.; this will take the name *nodicincta* v. Mts., and does not, as Suter reports, occur in Foveaux St. The Campbell Is. form I have not seen, but it is probably again distinct and has been named *Buccinum veneris* by Filhol (*Compt. Rend.*, vol. 91, p. 1094, 1880). As regards fossils, the nearest relative to *nassoides* is *E. elegantula verrucosa* Finlay,* which is quite close, but is smaller, has fewer axials on early whorls, and weaker spiral sculpture; *elegantula* itself is similar in habit to the Oamaru deep water form, but differs in amount of sculpture. Reduction of axials is carried still further in the older members such as *E. excoriata* Finlay. Dr. Marwick has described (*T.N.Z.I.*, vol. 58, pp. 486, 487, 1928) two Tertiary species from the Chatham Islands *E. bauckei* (Lower Miocene) being noted as directly ancestral to *elegantula* Finlay, and *E. ellisoni* (Middle Pliocene) as related to *nassoides*; the latter species while retaining the high spire of *nassoides*, has begun to show the inflation and size characteristic of *iredalei*.

Named after my good friend Mr. Tom Iredale, of the Australian Museum, Sydney.

Family Mitridae.

Austromitra Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 410.

Austromitra rubiginosa (Hutton, 1873). Suter, 1913, p. 366.

Common. The type is from the Chathams, but the species seems widely distributed. The single Oligocene species, *A. plicifera* Marwick (1928, p. 485) is not related.

Family Pyrenidae.

Zemitrella Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 431.

Zemitrella choava (Reeve, 1859). Suter, 1913, p. 431.

2 specimens, one of them corresponding to Suter's var. *e*. This species is at present used as a dumping-ground for *Zemitrellas* that cannot be allocated to any other described species, and I am not at all certain of the identification of the Chatham specimens, but a revision of the group must be left for another time. Marwick (1928, p. 488) has doubtfully identified a single specimen from Titirangi as this species.

Paxula Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 430.

Paxula n. sp. aff. *leptalea* (Suter, 1908).

The Chatham specimens, which are common, are all more or less worn, but probably identical with South Island shells which differ a little from the Rossian *leptalea*. It will therefore be better to take a Forsterian specimen as type, but for various reasons I think description is better withheld till the group can be treated as a whole.

Paxula sp. cf. **subantarctica** (Suter, 1908).

9 specimens are smaller and more slender than the preceding species, and may be provisionally referred here.

**T.N.Z.I.*, vol. 56, p. 241, 1926.

Paxula allani n. sp. (Figs. 38, 39).

Like *leptalea* in shape, but more elate, and with a higher spire. The specimens are all worn, and spiral sculpture on the whorls cannot be distinguished, but there are rather stout spiral cords over most of the base, more especially round the neck of the canal. The most characteristic feature of the species is the strong axial sculpture, which is obsolete in all other species of the genus so far described. The penultimate whorl bears 16 stout axials extending from suture to suture on all whorls, and across body-whorl and almost all the base; the ribs are broadly rounded and have subequal interstices. This gives it somewhat the appearance of a *Zafrina,* such as *subabnormis,* but the strong spiral sculpture is lacking, and the aperture, of course, is totally different, that of *Paxula* being highly characteristic.

Height, 6 mm.; diameter, 2.5 mm. Corresponding dimensions of a larger worn specimen, 8 x 3 mm.

Not uncommon, and apparently restricted to this locality. Named after Mr. R. S. Allan, Geologist to the Expedition.

Macrozafra Finlay, 1926; *T.N.Z.I.,* vol. 57, p. 431.

Macrozafra subabnormis saxatilis (Murdoch, 1905). *T.N.Z.I.,* vol. 37, p. 225.

9 specimens, all typically *saxatilis,* and not like Lyall Bay *subabnormis.* The differences between the two forms are slight, but as far as I have seen appear to be constant.

Family MURICIDAE.

Zeatrophon Finlay, 1926; *T.N.Z.I.,* vol. 57, p. 424.

Zeatrophon ambiguus (Philippi, 1844). Suter, 1913, p. 405.

2 specimens. Ancestral at the Chathams is the Nukumaruan *Z. mutabilis* Marwick (*T.N.Z.I.,* vol. 58, p. 488, 1928).

Xymene Iredale, 1915; *T.N.Z.I.,* vol. 47, p. 471.

Xymene plebejus (Hutton, 1873). Suter, 1913, p. 416.
5 specimens.

Axymene Finlay, 1926; *T.N.Z.I.,* vol. 57, p. 424.

Axymene traversi (Hutton, 1873). *Cat. Mar. Moll.,* p. 9. (Figs. 19, 20).

Common. I have shown (1926, p. 415) that this name has been wrongly interpreted by Suter. Although the species is very close to *corticatus* (Hutton), the name is worth retention, as the Chatham shells reach a much larger size, are wider, and have the ribs rather strongly tubercular on the periphery; the form seems to be restricted to the locality, as Hutton thought when he described it.

"Trophon paivae" and *"Trophon inferus"* are also recorded by Suter from the Chathams, but may be dismissed.

Family THAIDIDAE.

Lepsia Hutton, 1883; *T.N.Z.I.*, vol. 16, p. 222.

Lepsia haustrum (Martyn, 1784). Suter, 1913, p. 422.

A dozen specimens. This species does not seem to come much further south than Banks Peninsula. For reversion to *Lepsia*, vice *Haustrum* Perry, see Finlay, 1926, p. 427.

Neothais Iredale, 1912 (em.); *Proc. Mal. Soc.* (*Lond.*), vol. 10, p. 223.

Neothais scalaris (Menke, 1829). Suter, 1913, p. 423 (as *succincta*).

One specimen, of the "*textiliosa*" form. This is predominantly a Cookian shell, only just crossing Cook Strait as far as the main islands are concerned.

Lepsithais n. gen. Type: *Polytropa squamata* Hutton, 1878.

This is instituted to contain the strongly squamose Lepsiellas having two main spiral cords on the spire-whorls (with a third weak one present or absent above them), and eight regular thick spirals on the body-whorl, smooth except for the axial lamellation; axial ribs, if present, are numerous (12-16), weakly developed, and not spinose. True *Lepsiella* (type: *P. scobina* Q & G.), in contrast to this, has only one very strong medial keel on the spire-whorls, and two distant strong keels on the body-whorl (the type has often a third lower keel as strong as the others, and, in its southern form *albomarginata*, may have all the keels on the last whorl obsolete); axial ribs are strong when present, sparse (9-10), and produced into thick, more or less spinose nodules on periphery; the whole surface is covered with minute laciniate frills instead of regular axial lamellae. *Lepsiella* includes *scobina* (Q. and G.), *albomarginata* (Desh.), *rutila* (Suter), *botanica* Hedley, and *reticulata* (Blainv.), the last two being Australian. *Lepsithais* will cover *squamata* (Hutton), *lacunosa* (Brug.), *patens* (H. & J.), *youngi* n. sp. (*vide infra*), *vinosa* (Lk.), *aurea* (Hedley), and *propinqua* (Ten.-Woods), the last three again being Australian; they are on the whole larger than *Lepsiella*, *lacunosa* and especially *youngi* being much larger. The embryo of both these groups is paucispiral and rather tall, rather loosely coiled, the whorls somewhat globose and smooth, thus agreeing with the European *lapillus*, and differing radically from that of *Neothais* and *Agnewia*, which is sinusigerous, horny, sharply conic, polygyrate, swollen at its base, and set somewhat obliquely on the shell. I have not yet seen a perfect apex of *Buccinum lacunosum* Bruguiere, but all the shell features ally it to this series rather than to the *scalaris-succincta* association, which shows a different aperture. I have already noted (1926, p. 421) that *patens* and *squamata* are better referred to Thaididae than to Muricidae until the radular characters are reinvestigated; the series *patens*, *squamata*, *youngi* and *lacunosa* is so compact (and has even been thought by some to intergrade, though this needs investigation) that considerable evidence must be adduced before their dissociation can be agreed to. The Australian

members show axial sculpture; in the New Zealand shells this has become obsolete, except occasionally on the earliest whorls. *Adelaidae* is aberrant in having developed a very heavily thickened outer lip, like a *Morula.*

Lepsithais youngi n. sp. (Figs. 32, 33).

Shell related to *squamata* (Hutton), but very much larger and more solid, even rivalling *lacunosa* in size. The spiral cords are stronger and more projecting, quite like those of the Sydney *succincta*; they are more evenly distributed over the surface of the shell, and the interstices are notably wider (broader than the ribs instead of narrower). Axial laminations are rude and uneven, more distant and irregular. Columella stouter. Embryo as described for the genus.

Height, 53 mm.; diameter, 33 mm. (type).

This is what Suter has recorded (1913, p. 426) as *Thais striata* (Martyn) from the Chathams, but the affinity is undoubtedly rather with *squamata*; large examples may have been mistaken for the *succincta* form of *N. scalaris,* but the details of the aperture (especially the columellar characters) and protoconch separate it at once.

Named after Mr. Maxwell Young, Marine Biologist to the Expedition.

Lepsiella Iredale, 1912; *Proc Mal Soc.* (Lond.), vol. 10, p. 223.

Lepsiella scobina (Q. & G. 1833). Suter, 1913, p. 426.

Six examples, all, curiously enough, absolutely typical, and not referable to the Forsterian *albomarginata.* This recalls my record of typical *scobina* from one restricted locality in Dunedin harbour (*T.N.Z.I.*, vol. 55, p. 518, 1924).

Suborder PULMONATA.
Family ELLOBIIDAE.

Marinula King, 1835; *Zool. Journ.*, vol. 5, p. 343.

Marinula chathamensis n. sp. (Figs. 36, 37).

Differs from *filholi* in less compact whorling, *filholi* simulating a squat *Pupa,* while *chathamensis* has the last whorl more disproportionate and expanded on a slope as in *Limnaea.* The aperture is relatively considerably larger, quite like that of *Limnaea* or *Myxas* (= *Amphipeplea olim*) (apart, of course, from the teeth), the inner lip being excavated far further into the body-whorl, and the whole opening being more pear-shaped and less vertically compressed. Teeth slighter, the notch between the upper two being relatively larger and wider than in *filholi.*

Height, 7 mm.; diameter, 4 mm.

Two examples. Apparently a very distinct regional form.

Leuconopsis Hutton, 1884; *T.N.Z.I.*, vol. 16, p. 213.

Leuconopsis obsoleta (Hutton, 1878). Suter, 1913, p. 593.

One example.

Family Onchidiidae.

Onchidella Gray, 1850; *Fig. Moll. An.*, vol. 4, p. 117.

Onchidella flavescens Wissel, 1904. Suter, 1913, p. 810.

Onchidella nigricans (Q. & G., 1832). Suter, 1913, p. 810.

Onchidella patelloides (Q. & G., 1832). Suter, 1913, p. 810.
Suter reports these three species from the Chathams; no specimens were brought to me. Of the three, the last two are distributed in both main islands, but *flavescens* is otherwise reported only from North Auckland.

Family Siphonariidae.

Siphonaria Sowerby, 1824; *Gen. Shells*, fasc. 21, f. 22.

Siphonaria zelandica Q. & G., 1833. Suter, 1913, p. 600.
Common.

Gadinia Gray, 1824; *Philos. Mag.*, vol. 63, p. 274.

Gadinia nivea Hutton, 1878. Suter, 1913, p. 603.
9 specimens. This includes *Hipponyx hexagonus*, also recorded by Suter, but rejected by Powell (*Journ. Sci. and Tech.*, vol. 6, p. 282, 1924).

Suborder OPISTHOBRANCHIATA.
Family Pyramidellidae.

Odostomia Fleming, 1813; *Edinb. Encycl.*, vol. 7, p. 76.
The identification of the Recent species of this genus in New Zealand is impracticable until the Suter types are available, as most of them are so poorly figured. Two species have occurred to me in the Chatham material.

Gumina n. gen. Type: *Odostomia dolichostoma* Suter, 1908.
This shell differs in its capacious aperture, disproportionate body-whorl, position of plait, and curiously set nucleus from all the other New Zealand species, nor have I seen anything like it from Australia.

Gumina dolichostoma (Suter, 1908). Suter, 1913, p. 336.
One specimen. This is a very curious record, as I know of the species from only three other localities, Auckland (Suter's type), Doubtless Bay, and Awanui Heads—all typically Cookian.

Pyrgulina A.Ad., 1863; *Journ. Linn. Soc.*, vol. 7, p. 4.

Pyrgulina rugata (Hutton, 1886). Suter, 1913, p. 344.
5 examples.

Turbonilla Risso, 1826; *Hist. Nat. Eur. Merid.*, p. 224.

Turbonilla zelandica (Hutton, 1873). Suter, 1913, p. 332.
2 specimens.

Turbonilla n. sp.
One apical fragment, with coarser sculpture than *zelandica*.

Family STROMBIFORMIDAE.

Eulima Risso, 1826; *Hist. Nat. Eur. Merid.*, p. 123.

Eulima archeyi n. sp.

Small, subulate, perfectly straight, semi-transparent, polished. Milky-white outer layer, watery in appearance, where this is worn off. A few discontinuous very inconspicuous varices on the right side. Spire 3-4 times height of aperture. Embryo globular, obtuse. Whorls 9, regularly increasing, almost flat, bulging a little near lower suture, base strongly convex. Suture submargined by a more opaque band. Aperture shortly and broadly pyriform, somewhat effuse below. Outer and basal lips rather strongly convex. Columella and inner lip vertical, slightly separated from base, but not forming an umbilicus.

Height, 4.3 mm.; diameter, 1.5 mm.

Two examples. This seems close to *E. titahica* Suter (1913, p. 349), a species I have not seen, but apparently differs in its straight and rather higher spire.

Named after Mr. Gilbert Archey, Curator of the Auckland Museum.

Family ARCHITECTONICIDAE.

Philippia Gray, 1847; *Proc. Zool. Soc.* (*Lond.*), p. 146.

Philippia lutea (Lamarck, 1822). Suter, 1913, p. 316.

Reported by Suter; I have seen no specimens from the Chathams.

Family CAVOLINIDAE.

Cavolina Abildgaard, 1791; *Skr. Nat. Selsk.*, vol. 1, pt. 2, p. 175.

Cavolina telemus (Linné, 1758). Suter, 1913, p. 55.

Two examples.

Family TETHYDAE.

Tethys Linné, 1758; *Syst. Nat.*, ed. 10, p. 653.

Tethys brunnea (Hutton, 1875). Suter, 1913, p. 545.

One specimen, captured alive by Mr. M. Young. The shell agrees well enough with the figure and description, except that it is rather convex, and the left upper margin is almost straight and but little excavated. Shape, however, cannot be relied on too much in membranaceous shells, and I have a North Island shell which is but little convex, agrees still better with *brunnea,* but still has a straight upper margin.

Tethys n. sp. (?) aff. **tryoni** (Meinertzhagen, 1880), Suter, 1913 p. 545.

Six specimens, the largest measuring about 55 x 40 mm., differ from the preceding in greater elongation, acuminate base, little inflation, and generally different shape. The shape is somewhat that of *tryoni,* but there seems to be no right auricle, the left upper margin is not nearly so long and oblique, the base is distinctly narrowed

and subangled, there is certainly an inner calcareous layer (though it is very thin and fragile, falling to pieces on drying), and radial striation is quite prominently present. I feel fairly certain that a new species is represented, but careful comparisons with actual specimens and, if possible, anatomical investigation, are needed in this genus before separation is attempted; too many vague species of *Tethys* have already been described.

Family PLEUROBRANCHIDAE.

Bouvieria Vayssiere, 1896; *Journ. de Conch*, vol. 44, p. 116.

Bouvieria aurantiacus (Risso, 1818). Suter, 1913, p. 551.
Suter, on the authority of Schauinsland, reports this from the Chathams; I have not seen it.

Suborder NUDIBRANCHIATA.
Family FIONIDAE.

Fiona Forbes and Hanley, 1851; *Hist. Brit. Moll.*, vol. 3, p. x, note.

Fiona pinnata (Eschscholtz, 1831). Suter, 1913, p. 586 (as *marina*).
The remark made on the last species applies to this one also.

Class SCAPHOPODA.
Family DENTALIIDAE.

Fissidentalium Fischer, 1885; *Man. de Conch.*, p. 894.

Fissidentalium zelandicum (Sowerby, 1860). Suter, 1913, p. 819.
One very much worn specimen. Suter reports only *Dentalium opacum* Sow. from the Chathams, but that species seems to be a very vague one, and improbably from New Zealand. The New Zealand members as a whole are very badly in need of revision, and in the meantime it seems best to recognize only one large Recent species, *zelandicum*. I have examined the single specimen in the Canterbury Museum which is the basis of the sole record of *opacum* from New Zealand; it is worn smooth and eroded to a mere fraction of its original thickness. It cannot possibly be identified and should have been thrown away.

Class PELECYPODA.
Order PRIONODESMACEA.
Family NUCULIDAE.

Nucula Lamarck, 1799; *Mem. Soc. N.H., Paris*, p. 87.

Nucula nitidula A. Adams, 1856. Suter, 1913, p. 833.
2 specimens.

Nucula dunedinensis n. sp. (Figs. 1, 2, 43, 44.)
Shell very small, like a *Pronucula*, but with typical hinge; concentric sculpture strong, radial very weak. Ventricose, triangularly

ovate, light greyish-brown. Beaks at posterior third, inconspicuous. Anterior end rather bluntly rounded, the dorsal margin with a slight medial bulge; posterior end somewhat produced and subangled; basal margin flatly convex. Lunule and escutcheon both wide, especially the former, but indistinctly indicated. In sculpture a miniature replica of *Tawera subsulcata* (Sut.), i.e., with strong concentric ribs, regular medially, but a little anastomosing at sides, ridge of ribs nearer umbo, interstices narrower; lower surface of ribs slightly frilled by close and fine radials, more distinct at sides. Margins crenulated. Resilium pit strong, not much oblique, hinge with about nine anterior and six posterior teeth, decreasing regularly towards, and meeting under, umbo. Interior smooth and nacreous, but little of sculpture visible in adult shells. Characteristic of the species is a thickened radial ridge extending internally from umbo for a short distance towards centre of base, usually accompanied externally by one or two short irregular radial furrows immediately below nepionic shell.

Length, 2 mm.; height, 1.8 mm.; diameter, 1.1. mm.

Locality: Dunedin Harbour, dredged in 3 fathoms (type); Chatham Is., one perfect specimen.

The single Chatham specimen has the infra-nepionic furrows so well developed that the sculpture of *Acila* is simulated over that area; this, however, may not be constant.

The species is similar to *N. hartvigiana* Pf. in its strong concentric sculpture (though the ribs are relatively a little higher and stronger, and the interstices wider), but differs in small size, shape, etc. Distinct regional forms of this species occur in the North Island and at the Subantarctic Islands.

Family ARCIDAE.

Barbatia Gray, 1847; *P.Z.S. Lond.*, pt. 15, p. 197.

Barbatia novaezelandiae Smith, 1915. Suter, *N.Z.G.S. Pal. Bull., No. 5*, p. 82, 1917.

2 specimens.

Glycimeris da Costa, 1778; *Brit. Conch.*, p. 168.

Glycimeris laticostata (Q. & G., 1835). Suter, 1913, p. 851.

Numerous examples. The species existed there also in the Pliocene, and had an ancestral relative, *G. traversi* (Hutton), in the Oligocene (see Marwick, *T.N.Z.I.*, vol. 58, p. 442, 1928).

Family PHILOBRYIDAE.

Hochstetteria Velain, 1878; *Archiv Zool. Exper. Generale*, vol. 6, p. 129.

Hochstetteria meleagrina Bernard, 1896. Suter, 1913, p. 859 (as *Philobrya*).

This is reported by Suter, on Professor H. B. Kirk's authority, from the Chatham Is., "in roots of *Macrocystis*"; it has not occurred to me.

Family OSTREIDAE.

Ostrea Linné, 1758; *Syst. Nat.*, ed. 10, p. 696.

Ostrea sinuata Lamk., 1819. Iredale, 1924, p. 191.

Numerous examples.

The number of species of New Zealand oysters and the correct names for them has always been a disputed point, and no finality has yet been obtained. Hutton gave one opinion in his *Catalogue* of 1873, and altered it in his *Manual* of 1880. Suter gives a quite different account in his own *Manual* of 1913. Later (*N.Z.G.S. Pal. Bull., No. 5*, p. 86, 1917), in a note on *Eostrea* Ihering, he re-groups the species and proposes the name *Anodontostrea* for forms without dorsal marginal crenations; to place this name on a more scientific basis I here nominate his first species, *O. angasi* Sow. as the type species. Oliver then followed with a discussion (*Proc. Mal. Soc.*, vol. 15, pt. 4, p. 182, 1923) as to the validity of some of the species admitted by Suter; the six Recent forms given by him in the *Manual* are reduced to four by Oliver, *reniformis* Sow. being dismissed as probably indeterminable and certainly not Neozelanic, and the Dunedin rock-oyster (Suter's *tatei*) being synonymised with *angasi* Sow. Marwick (*Rep. A.A.A.S.*, vol. 16, p. 324, 1924) continued the reduction of species by rejecting the records of two Australian Tertiary forms, *arenicola* Tate and *manubriata* Tate. This tendency, indeed, had been forecasted by Suter, who remarked (1913, p. 892) that " extended observations . . . may lead to a reduction of species." The latest comment on New Zealand oysters comes from Iredale (1924, p. 192) who, noting that *O. virescens* Angas, 1867, having supplanted the name *angasi* Sow., 1871, in Australia, must in turn give way to the still earlier *O. sinuata* Lamk., 1819, remarks that "The Neozelanic species known by the latter name (*angasi*) seems to be a distinct species."

It is my proposal here to try to simplify matters still further. The presence or absence of marginal crenulations, far from being of sectional importance, as Suter always held, is, I submit, so variable and inconstant as to be valueless in most cases to separate even species. Chapman (*P.R.S. Vict.*, vol. 35, N.S., p. 3, 1922) notes that *O. ingens* Zitt., referred by Suter to *Anodontostrea*, often has distinctly crenate margins. Cossmann (*Rev. Crit. Pal.*, 1918, p, 26), in reviewing Suter's proposal of this section, remarks, "mais cette distinction est bien fragile et ne justifie pas l'adoption d'un nouveau nom." My own experience leads me to suspect that even *O. corrugata* auct. (not of Hutton),* kept separate by all writers so far, is not

*Dr. Marwick writes to me regarding this species: " The shells usually called *O. corrugata* are not this species. Indeed, I have not seen a duplicate of the type, which seems to be quite distinct from *O. angasi*. Its locality is certainly not Shakespeare Cliff as given by Hutton. It is from a beach outcrop, and may be from the coastline between Wanganui and Hawera." The specific name, however, cannot be maintained, as there is a prior *Ostrea corrugata* Brocchi, 1814 (*Conch. Subap.*, p. 670); I therefore re-name Hutton's New Zealand shell *Ostrea fococarens* nom. nov. It has an upper valve like *sinuata*, a large area of attachment, and an erect lower valve with many ribs, 33 at least; it reaches a size between *hefferdi* (v.a.) and *sinuata*, and was evidently a rock form. *O. corrugata* Nomland, 1917, an American species, has been discussed by Hanna (*Proc. Cal. Acad. Sci.*, vol. 13, No. 7, p. 174).

satisfactorily separable from *angasi* Sow., whether one takes Recent forms or Pliocene fossils. With this proviso, which I think reasonable until anatomical investigations can settle the matter definitely, I am also unable at present to see differential characters between New Zealand and Australian specimens. Hutton's name *O. lutaria* (*C.M.M.*, p. 84, 1873) would be available for New Zealand shells, were they to prove distinct. The name *O. tatei* Suter must be dismissed altogether from New Zealand lists; it can be construed only as a substitute name for *O. hippopus* Tate, *non* Lamarck; although Suter described a New Zealand Recent specimen under this name at its introduction, and referred to a figure of it, the "Atlas" was not then published, and a complication is thus avoided; the letters "n.n." after the name, taken in conjunction with the line that follows, indicate definitely that the name *tatei* must be restricted to the Australian Eocene species. Even in this category it is of doubtful standing, for Tate had long ago (*Trans. Roy. Soc. S.A.*, vol. 23, p. 268, 1889) noted the preoccupation of his name, but did not re-name the unique specimen, as he considered it "an individual monstrosity of *Gryphaea tarda.*" If this is really so, the name *Notostrea tatei* (Suter) will take precedence of my *N. lubra* (v.a.) for the Australian form, but Tate's figure shows a shell very unlike *tarda.* In spite of Oliver's pronouncement (*v.a.*), I think that the difference in habitat requires that the Dunedin rock-oyster and the Stewart Island mud-oyster be kept specifically apart. The shells are recognizably different, much more so than many of the fossil species; so, as the name *tatei* is inadmissable, I now give the name *Ostrea hefferdi* n. sp. to the New Zealand form described and figured by Suter (*Man. Moll.*, p. 889, 1913; Pl. 57, f. 4). For reasons stated in the "Further Commentary" (Finlay, 1926, p. 353), I select as neotype a specimen in my collection from Dunedin Harbour; the specific name is given in compliment to Mr. Hefferd, Director of New Zealand Fisheries.

I have not had very many Australian specimens of *sinuata* for comparison, and it is possible that differential characters may be observable in the upper valve, but till long suites from both sides can be examined I prefer to unite *virescens* Angas, *angasi* Sow., *lutaria* Hutton, and *corrugata* auct., not of Hutton, under the one name, *sinuata* Lamk. (not to be confounded with *sinuosa* Gmelin, 1791).

As the oysters of New Zealand have suffered so many vicissitudes, I append a list of the species at present admitted to our fauna, and a suggested revised grouping of these species:—

Ostrea s. str.—*sinuata* Lamk., *hefferdi* Finlay, *fococarens* Finlay, and *O. charlottae* n. sp. for "*O. hyotis*" Suter, *Man. N.Z. Moll.*, p. 889; Pl. 57, Fig. 2; not of Linné. The introduction of this name into Austral lists is due to Tate, who doubtfully referred to it an Australian Middle Tertiary form; Suter continued this bad usage by so identifying New Zealand Recent shells from Queen Charlotte Sound. Tate himself expunged the name from Australian lists in 1899 (*Trans. Roy. Soc. S.A.*, vol. 23, p. 268) as soon as he saw true specimens of *hyotis,* and I now do the same for New Zealand. The species is distinct from *sinuata,* and seems more constant in habit than most oysters, it is not uncommon in 60 fathoms off Otago Heads. As holotype of my species I choose a specimen in my collection from

Queen Charlotte Sound (Figs. 25, 26). The three Oligocene Chatham species, *cannoni, waitangiensis,* and *arcula,* all of Marwick (*T.N.Z.I.*, vol. 58, p. 462, 1928), may also be referred here.

Gigantostrea Sacco, 1897—*wullerstorfi* Zittel,† *mackayi* Suter,‡ and *wollastoni* Finlay (*incurva* Hutton,† preoccupied, see *T.N.Z.I.*, vol. 57, p. 528, 1927).

Crassostrea Sacco, 1897—*ingens* Zitt.,* and *nelsoniana* Zitt. The type localities (and their ages) of these two species are not the same, so both names may be retained in the meantime. Chapman (*P.R.S. Vict.*, vol. 35, N.S., p. 2, 1922) has synonymized them and included also *O. hatcheri* Ortmann, when recording *ingens* from the Australian Tertiary, but it is likely that both his identifications and those of Hatcher and Ortmann as regards South American records of Zittel's species are incorrect; typical *ingens* seems to be Pliocene (Marwick, *in litt.*), while the Australian and American shells are Miocene or older.

Lopha Bolten, 1798—*glomerata* Gould (*cucullata* auct., *v.i.*), *gudexi* Suter,‡ and *pahiensis* n. sp. for "*O. gudexi*" Marshall and Murdoch, *T.N.Z.I.*, vol. 53, p. 77, 1921; Pl. 15, Fig. 1; not of Suter. The two fossils are somewhat different in type from the Recent shell, which has not long (geologically) been a member of the fauna, but all may be included in *Lopha* (=*Alectryonia*) for the present.

Notostrea Finlay, 1928 (in Marwick, 1928, p. 432),— proposed for *Ostrea subdentata* Hutton* (*Cat. Tert. Moll.*, p. 34, 1873). This curious little oyster will not fall into any of the above groups, and presents a facies all its own. Only the type, a left valve, was known to Hutton and Suter, but I have four topotypes representing complete specimens and the other valve. The latter is rather flat, small, thick, deeply excavated for the animal cavity, with a very broad bevelled flange forming the margins; for some distance on each side of the umbo there is a wide sunken space in this flange finely but strongly corrugate-granulose; the muscle scar is tiny, high up, and well to the side (⅜—⅜ of height and width). The left valve is concave, much smaller than the right, fitting tightly into the body cavity and not overlapping on the bevel, the umbo bent backwards so that the beaks are wide apart in the closed shell and show the full extent of the short hinge and ligament pit. Only concentric sculpture is present, the right valve almost smooth except for growth lines, the left valve with rather strong and broad lamellae. Suter, because of the crenulated margins, placed the species in *Eostrea* Ihering, which he later (*N.Z.G.S. Pal. Bull. No. 5*, p. 86, 1917) decided was a synonym of *Ostrea* s. str., where he therefore left it; by no stretch of imagination, however, can it be regarded as congeneric with the British *O. edulis*, the genotype. Cossmann (*Rev. Crit. Pal.* No. 20, p. 10, 1916) in his review of Suter's work remarks that the reason for the use of *Eostrea* for the species is not indicated, " n'est ce pas *Liostrea* Douv.?" This, however, is a Cretaceous genus (type: *O. sublamellosa* Dkr.) with subequal valves and fine radiating striae;

*N.Z.G.S. *Pal. Bull. No. 2*, p. 46, 1914.
† „ „ „ *No. 3*, p. 53, 1915.
‡ „ „ „ *No. 5*, p. 71, 1917.

the subgenus *Ostreinella* Cossmann (type: *O. neglecta* Micht.; Miocene) is just as inapplicable, having also subequal, fragile valves. In all characters except curvature, however, *O. subdentata* seems closely related to *Gryphaea tarda* Hutton (see Marwick, *T.N.Z.I.*, vol. 58, p. 462, 1928) a species that has previously seemed without allies. Cossmann, at the reference above given, mentions that the generic name *Liogryphaea* Fischer ought more properly to have been used, *Gryphaea* Lk. being based on the Recent *G. angulata* Lk., and thus practically synonymous with *Ostrea*. But, according to Dall (*Trans. Wag. Free Inst.*, vol. 3, pt. 4, p. 673, 1898), *Gryphaea* was introduced by Lamarck in 1801 with nine species, three of which, including *G. angulata*, were *nomina nuda*. This, therefore, cannot be the type. He goes on, "As Lamarck selected no type, the type must be sought from the first reviser. This was Bosc, in the following year, who cites the described species, and figures as an example the *G. arcuata*, which he refers to the *Anomia gryphus* of Linné." This *G. arcuata* is close to, if not identical with *G. incurva* Sow., of the Liassic. Nevertheless, the mere citing or even figuring of an example of a genus is not held by the rules to be the definite selection of a type, and it would seem that this problem still needs investigation as to who first definitely and legally named a type for *Gryphaea* from amongst the valid species. Cossmann and Peyrot (*Conch. Neogen. de L'Aquit.* vol. 2, pt. 2, p. 389, 1914) treat *Crassostrea* as merely a divison of the true *Gryphaea*, and state (l.c., p. 376) that "*Liogryphaea* abondant dans le Jurassique, et remplacé dans le Crétacique et le Tertiaire par *Pycnodonta* qui y ressemble beaucoup." It is evident that neither *Gryphaea* nor *Liogryphaea* can be used for *tarda*, which is an Oligocene species; *Pycnodonta* is somewhat like it, but has a large muscle scar, placed low down, and a rather different hinge; it is unlikely that *tarda* is closely related to these northern stocks, and for the present it seems best to refer it also, in spite of its curvature, to *Notostrea*. It is known that the *Gryphaea* form has arisen at different times in the Mesozoic from different stocks of oysters (see, for example, Trueman in *Geol. Mag.*, 1922, p. 256), so that the resemblance of *tarda* to such Cretaceous forms as *vesicularis* Lk. is probably purely fortuitous. Further separation can be effected later if the discovery of allies of *subdentata* and *tarda* shows that two stocks are represented. The Australian Tertiary shells referred, with doubt, by Tate (*Trans. Roy. Soc. S.A.*, vol. 8, p. 98, 1886) and Harris (*Cat. Tert. Moll. B.M.*, p. 302, 1897) to *tarda* are a distinct species, specimens in my collection showing that the posterior lobation is higher up and starts nearer the umbo, attaining its maximum medially instead of near the base as in *tarda*; the surface is rather more rugose and knobby, and the hinge crenulations apparently stronger. For the Great Australian Bight specimen figured by Tate (*Trans. Roy. Soc. S.A.*, vol. 8; Pl. 6, Figs. 2 a, b) I have therefore supplied the new name *Notostrea lubra* (in Marwick, 1928, p. 432).

If *O. sinuata* Lk. is ever regarded, on anatomical or other grounds, as generically separable from *O. edulis* L., Suter's name *Anodontostrea* will be available for it and the other Austral forms referred to *Ostrea* s. str.

Lopha Bolten, 1798; *Mus. Bolten.*, pt. 2, p. 168.

Lopha glomerata (Gould, 1850). Suter, 1913, p. 891.

5 examples. This is a remarkable occurrence; Suter gives the range of the species as "Northern part of the North Island," and Hutton (*Man. N.Z. Moll.*, p. 175, 1880) gives it as from "Auckland; not found further south." This species, *Lepsiella scobina*, and a few others, form a curious and distinct Cookian element in the Chatham fauna.

As regards the specific name, Iredale (1924, p. 192) has shown that *cucullata* Born does not apply to the Austral species, so that Gould's *glomerata*, described from New Zealand, may be resumed for the Auckland rock-oyster.

Family Pectinidae.

Notovola Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 451.

Notovola novaezelandiae (Reeve, 1852). Iredale, 1924, p. 193.

4 mutilated valves, which show no subspecific variation from the Mainland shells.

Chlamys Bolten, 1798; *Mus. Bolten.*, pt. 2, p. 161.

Chlamys celator n. sp. (Figs. 49, 50).

Shell very similar to *C. zelandiae* (Gray), but much larger, and with stronger, more prickly ribs; living in sponges. There are somewhere about a dozen main ribs on each valve; those of the right valve double, and separating into two or three near margin; those of the left valve single, and thus apparently more distant. More or less regular primary, secondary, and tertiary interstitial riblets, in decreasing order of prominence, are present; this arrangement is better marked on left valve, the interstitial ribs on right valve being finer and more or less equal. All ribs, especially main ones, studded with sharp, high, narrowly spout-like scales. This sculpture is just that of *zelandiae* much exaggerated. The shell, too, has much the same style of build, but is notably less elongated, the dorsal margins sloping less steeply and spreading outwards lower down. Shell rather more inflated, and still ruder in growth-habit than *zelandiae*, *i.e.*, there are frequent kinks in the shell, the convexity and the outline of basal margin are highly irregular. This feature is characteristic of the *zelandiae* as opposed to the *radiatus* forms. Apparently normally living in sponges, every fresh specimen seen being totally incrusted with them; never found attached to rocks on the littoral.

Length, 40 mm.; height, 43 mm.

Locality: Stewart Is. (type; common); South Island beaches; Chatham Is., common.

This is Suter's "subsp. *gemmulatus*" of *C. zelandiae*, but not, as Iredale has noted (1915, p. 486), *gemmulatus* Reeve. His description is not very good, but his figure and localities show that he had this form in mind. Whether it is really the Forsterian regional representative of the Cookian *zelandiae*, I am uncertain, so I have taken the safest course of describing it as a distinct species; it is unquestionably closely allied in habit and sculpture, but the habitat is notably different, while, on the other hand, there *is* another species in the south that lives under rocks and on roots of seaweed, just as

zelandiae does in the north. This form is distinct from both the others and is described below as *C. suprasilis* n. sp. The two new species are both found fossil in the Upper Pliocene beds at Castlecliff, but true *zelandiae* is not. A specimen of *zelandiae* (from Motutapu Island, under stones at low water) is here illustrated (Fig. 51) for comparison with *celator*. *C. zelandiae* (Gray) and *C. grangei* Murdoch, 1924, should be added to the list of New Zealand *Chlamys* given by Marwick (*T.N.Z.I.*, vol. 58, p. 453, 1928), these two species being inadvertently omitted.

Chlamys suprasilis n. sp. (Figs. 52, 53, 54, 55).

At first sight merely a worn *celator*, but the scaling is different. Shell almost exactly like *celator* in habit and style of sculpture, but relatively a little wider and more compressed vertically, the basal margin being less convex and shorter, and the dorsal margins meeting at a wider angle. Both valves less convex, especially the right, which, in its early stages is generally flattish or even concave. Typically, spinous sculpture is obsolete over most of the shell, the strong main ribs (double in the right valve) present as in *celator*, but with only one fairly strong interstitial riblet, and all ribs and interstices perfectly smooth and polished, as if secondary sculpture had been heavily erased. This stage may last over the whole shell; more frequently there are a few sparse scales towards the lower margin, or the smooth area may cease suddenly and give way to a spinose surface just as in *celator*; occasionally spinose sculpture may be developed over most or all of the surface. The scales, however, are of a different style, not close, high, and narrowly spout-like, situated on sharply angular ribs, but rather distant, low, broadly subtubular, and placed on wide, rounded ribs. The ears of both species are spinose, but the same difference in the scales is observable.

Length, 33 mm.; height, 33 mm.

Locality: Port Chalmers, near Dunedin (type and others, from rubbish scraped from the bottom of a ship which had been in dock for several years); Dowling Bay, Dunedin Harbour, attached to stones at low water mark; Taieri Beach; Chatham Is., not uncommon. Fossil at Castlecliff.

It is often difficult to assign beach-worn valves to *celator* or *suprasilis* with certainty, but fresh specimens are easily separated.

In colour the two new species show the same variation as is seen in *zelandiae*; it has not been thought worth while to detail it.

Chlamys radiatus (Hutton, 1873). Suter, 1913, p. 877.

15 valves, agreeing exactly with topotypes, but without their characteristic reddish tint, pale-coloured like northern examples. This stock is represented in Oligocene beds at the Chathams by *C. chathamensis* (Hutton) and *C. seymouri* Marwick (*T.N.Z.I.*, vol. 58, pp. 456, 457, 1928).

The triangular triple ribbing on the upper part of the valves of *radiatus* is so characteristic that the species can hardly be mistaken.

Chlamys dichrous Suter, 1909. Suter, 1913, p. 875.

8 valves. This species has been difficult to identify satisfactorily, and does not appear to be well known. It seems to intergrade by

stages with *radiatus*, nevertheless, the extremes are so distinct that the name is worth retaining. It is just possible that the form represents a hybrid between *radiatus* and *celator*, it always occurs where these two species are plentiful, but is much rarer, and I have not seen it when either of the other two are absent. It differs from *radiatus* mainly in development of sculpture, which approaches that of *celator*. The main ribs become increasingly instead of decreasingly prominent anteriorly, so that at the margin there are still some 20 strong ribs, bordered closely on each side by lateral riblets, and with still weaker riblets developed for a short distance in the interstices, instead of about 80 subequal fine ribs as in *radiatus*. There is the same triple arrangement on the early part of the valves as in the latter species, but the lateral riblets do not separate far from nor reach the size of the main ribs. A superficial likeness to *celator* is thus developed, but the triple ribbing is different in detail, and the scaling very much finer, closer, and lower, and the whole ornament is seen on inspection to be that of *radiatus* rather than of *zelandiae*; this is more quickly apparent on the right valve, where the double ribbing of *zelandiae* and *celator* is absent in *dichrous* and *radiatus*. Occasionally the ribs are thin and distant, and the species is then very like the fossil *chathamensis* (Hutton); Suter has compared the two, and states that the latter has no ctenolium or byssal notch—this is quite wrong. *C. oamarutica* Murdoch (*T.N.Z.I.*, vol. 55, p. 158, 1924) is another allied fossil species from the Mainland, while two other Oligocene Chatham species *C. mercuria* Marw. and *C. titirangiensis* Marw. (*T.N.Z.I.*, vol. 58, pp. 457, 458, 1928) are perhaps related. Iredale (*Rec. Austr. Mus.*, vol. 14, No. 4, p. 252, 1925) has described *C. famigerator* nov. which he compares with *dichrous*, but the peculiar sculpture which he takes as characteristic of the latter species (scales only on every third or fourth rib in left valve, others smooth) is the exception rather than the rule; I have seen only one valve that showed it, scales being generally present on all ribs, though every third or fourth may have them a little stronger—this, however, also occurs sometimes in *celator*.

Dichrous is, as a rule, less expanded laterally and inclined to be of more convex and irregular growth than *radiatus*. To aid in identification of the species, figures of Chatham specimens are here presented (Figs. 45, 46, 47, 48).

It may be noted that Suter described the species from specimens found in the stomach of a blue cod caught at Stewart Is.; all the Chatham specimens were also obtained from cods' stomachs, so it appears to be a regular constituent of their food.

Pallium Schumacher, 1817; *Essai Nouv. Syst.*

Pallium convexus (Q. & G., 1835). Suter, 1913, p. 879.

17 valves. Closely related in the Oligocene of Momoe-a-toa is *P. dendyi* (Hutton) (Marwick, *T.N.Z.I.*, vol. 58, p. 458, 1928).

Family LIMIDAE.

Limatula Wood, 1839; *Ann. Mag. Nat. Hist.*, vol. 3, p. 260.

Limatula maoria Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 454.

11 valves, of slightly larger size than usual, but otherwise typical. In lineage at the Chathams is the Oligocene *L. morioria* Marwick

(*T.N.Z.I.*, vol. 58, p. 461, 1928), while *maoria* itself lived there in Pliocene times.

Family ANOMIIDAE.

Monia Gray, 1850; *Proc. Zool. Soc.*, 1849, p. 121.

Monia zelandica (Gray, 1843). Suter, 1913, p. 845.

5 examples. *Monia furcilla* Marwick (*T.N.Z. I.*, vol. 58, p. 444, 1928) is compared by its author rather to *M. furcata* (Hutton).

Family MYTILIDAE.

Mytilus Linné, 1758; *Syst. Nat.*, ed. 10, p. 704.

Mytilus "planulatus Lamk., 1819." Oliver, *Proc. Mal. Soc.* vol. 15, p. 181, 1923.

One large complete specimen. Iredale has noted (1924, p. 195) that the use of this name for New Zealand shells should be reconsidered. As it has not yet been settled whether the Peronian *obscurus* Dkr. can be satisfactorily separated from the West Australian *planulatus*, and which of the two is nearer to the New Zealand form and as no Australian examples are available to me for actual comparison, it is best to postpone rejection of the name selected by Oliver until a stable substitute can be found.

Aulacomya Moerch, 1853; *Cat. Conch. Yoldi*, pt. 2, p. 53.

Aulacomya maoriana (Iredale, 1915). *T.N.Z.I.*, vol. 47, p. 484.

A few shells. Also present in the Pliocene of Titirangi (Marwick, 1928, p. 444) while a related form, *A. willetsi* Marwick, occurs in the Oligocene.

Modiolus Lamk., 1799; *Mem. Soc. N.H. Paris*, p. 87.

Modiolus areolatus Gould, 1850. Hedley, *P.L.S., N.S.W.*, vol. 48, p. 302, 1923.

Common. This is Suter's *M. australis* Gray (1913, p. 867), a name rejected by Hedley as practically indeterminable, and not applicable to a southern form.

Modiolus fluviatilis (Hutton, 1878). Suter, 1913, p 867.

Many examples. The species was described from this locality, and I have not been able to match Chatham specimens with any from the Mainland. I have not seen North Island shells, but South Island specimens—which would be the most likely to agree— are constantly heavier in build, more tumid, with a stronger umbonal carina, and much higher and more swollen beaks. I am inclined to think that the latter represent a new species, and that *fluviatilis* is restricted to the Chathams. This discrepancy in purely Neozelanic forms is sufficient evidence for rejecting Oliver's proposal (*Proc. Mal. Soc.*, vol. 15, p. 181, 1923) to replace Hutton's name by *confusus* (Angas, 1871) provided for a Sydney species. *Fluviatilis* is common at the Chathams, at the mouth of the Waipapa River, in company with *Potamopyrgus*, and many of the specimens are notably fragile and deficient in lime, recalling the condition of *Austrovenus stutchburyi* in the Lagoon.

Trichomusculus Iredale, 1924; *P.L.S., N.S.W.*, vol. 49, pt. 3, p. 196.

Trichomusculus barbatus (Reeve, 1858). Suter, 1913, p. 868.
4 specimens.

Musculus Bolten, 1798; *Mus. Bolten.*, p. 156.

Musculus impactus (Hermann, 1782). Suter, 1913, p. 869.
Common.

Family Gaimardiidae.

Gaimardia Gould, 1852; *U.S. Expl. Exped.*, vol. 12, p. 459.

Gaimardia forsteriana Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 456.

4 specimens. The allied genus *Neogaimardia* Odhner was not found in the recent collections but Marwick has reported a Pliocene species from the Chathams (*N. elegantula*; *T.N.Z.I.*, vol. 58, p. 463, 1928).

Costokidderia Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 457.

Costokidderia costata (Odhner, 1924). *Pap. Mort. Pacific Exped.*, No. 19, p. 68.

One example. I am still unable to separate Taieri Beach examples from topotypes of Odhner's species, the sculpture and shape agreeing exactly, while *lyallensis* and *pedica* (both of Finlay., *loc. cit.*) differ at sight in the notably narrower interstices between the ribs. This leads to an apparently anomalous distribution, *costata* ranging from Auckland Is. to Chatham Is., while the distinct *pedica* occurs in between at the Snares. All the examples of *costata*, however, come from extremely littoral situations, while the Snares shells are from 50 fathoms, so it is probable that bathymetric rather than regional forms are represented, and that shells gathered from littoral seaweeds at the Snares would agree with *costata*. The single Chatham specimen agrees fairly well with Taieri Beach examples, but further material might quite possibly indicate a distinct regional form.

Order ANOMALODESMACEA.
Family Myochamidae.

Myadora Gray, 1840; *Ann. Mag. Nat. Hist.*, p. 306.

Myadora boltoni Smith, 1880. Suter, 1913, p. 1027.
Reported by Suter; I have not seen it.

Family Cleidothaeridae.

Cleidothaerus Stutchbury, 1830; *Zool. Journ.*, vol. 5, p. 97.

Cleidothaerus maorianus Finlay, 1926. *T.N.Z.I.*, vol. 57, p. 474.

One worn example; otherwise reported only from the Cookian region.

Order TELEODESMACEA.

Family CARDITIDAE.

Cardita Bruguière, 1792; *Ency. Meth.*, vers. 2, p. 401.

Cardita aoteana Finlay, 1926; *T.N.Z.I.*, vol., 57, p. 459.

Common. A closely related Tertiary form at the Chathams is *C. northcrofti* Marwick from the Oligocene of Whenuataru peninsula (see *T.N.Z.I.*, vol. 58, p. 464, 1928).

Venericardia Lamk., 1801; *Syst. An. s. vert.*, p. 123.

Venericardia purpurata (Desh., 1854). Suter, 1913, p. 905.

4 valves. *V. beata* and *nuntia* from Oligocene beds, and *V. martini* from the Pliocene (all of Marwick; see *T.N.Z.I.*, vol. 58, pp. 465, 466, 1928) represent this species in the Tertiary Chatham faunas.

Family CONDYLOCARDIIDAE.

Condylocardia Bernard, 1896; *Bull. Mus. d'Hist. Nat., Paris*, vol. 2, p. 195.

Condylocardia crassicosta Bernard, 1896. Suter, 1913, p. 911.

One example. The species described by Marwick from the Pliocene of Titirangi (*C. torquata*; *T.N.Z.I.*, vol. 58, p. 466, 1928) is of quite a different style.

Family LUCINIDAE.

Divaricella von Martens, 1880; *Beitr. Meersf. Mauritius*, p. 321.

Divaricella cumingi (Ad. & Ang., 1863). Suter, 1913, p. 913.

9 valves.

Family UNGULINIDAE.

This is Family Diplodontidae of American, Australian, and New Zealand writers. The name is due originally to Dall, but in his list of genera comprising the family he includes *Ungulina* Daudin, 1802, which is much the oldest generic name of those admitted. Cossmann and Peyrot (*Conch. Neogen. l'Aquitane*, tome 1, pt. 3, p. 617, 1912), Harris (*Cat. Tert. Moll. B.M.*, pt. 1, p. 375, 1897), Newton (*Brit. Olig. and Eocene Moll.*, p. 47, 1891), Stolickza (*Cret. Pelec., Pal. Indica*, vol. 3, p. 259, 1871), and others seem, therefore, to be more correct in using the family name Ungulinidae proposed by H. & A. Adams in 1857 (*Gen. Rec. Moll.*, vol. 2, p. 470).

Zemysia Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 462.

Zemysia zelandica (Gray, 1835). Suter, 1913, p. 917.

One worn valve. Common in the Pliocene (Marwick, 1928, 467).

Zemysina Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 462.

Zemysina striatula Finlay, 1926; *l.c.*, p. 462.

5 complete shells, all juvenile, but apparently less inflated than usual.

Family Erycinidae.

Melliteryx Iredale, 1924; *P.L.S., N.S.W.*, vol. 49, pt. 3, p. 207.

Melliteryx parva (Desh., 1856). Suter, 1913, p. 922.
One valve.

Myllitella Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 464.

Myllitella pinguis Marwick, 1928. *T.N.Z.I.*, vol. 58, p. 467, 1928.
Common in shell sand. I cannot separate the Recent specimens from the Titirangi Pliocene fossils.

The species differs from the Recent Cookian *M. vivens* Finlay (1926, p. 464) in larger size, rather stronger shell, sloping dorsal sides meeting at a distinct angle (instead of running almost straight across under the beak), and relatively much more solid hinge, the laterals being especially strong and projecting considerably into the valves as in *Lasaea*; the ornamentation seems slightly finer.

Notolepton Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 463.

Notolepton sanguineum (Hutton, 1883). Suter, 1913, p. 925.
Not uncommon.

Mysella Angas, 1877; *Proc. Zool. Soc. Lond.*, p. 176.

Mysella unidentata (Odhner, 1924). *Pap. Mort. Pacific Exped.* No. 19, p. 76.
6 complete specimens. This is Suter's "*Rochfortia donaciformis.*"

Rochefortula Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 465.

Rochefortula reniformis (Suter, 1908). Suter, 1913, p. 931.
2 examples.

Family Kellyidae.

Kellya Turton, 1822, emended; *Dithyra Brit.*, p. 56.

Kellya suborbicularis (Montagu, 1804). Suter, 1913, p. 923.
3 valves.

Family Lasaeidae.

Cossmann and Peyrot (*Conch. Neogen. l'Aquitane,* Tome 1, pt. 3, p. 543, 1912) have decided to adopt Gray's family name for the Lasaeas, and this has been followed by Odhner (1924, p. 78).

Lasaea Brown, 1827; *Ill. Conch. Gt. Britain,* Explan. pl. 20, f. 18.

Lasaea hinemoa n. sp. (Figs. 27, 28).
Shell close to *L. australis* (Lamk.), but smaller. Darker coloured, entirely dark reddish or reddish-brown instead of largely whitish. A little less elongate and more regularly quadrilaterally oval, the dorsal margina forming an almost straight line under the beaks; in *australis* the posterior dorsal margin slopes suddenly down at the

umbo to meet anterior dorsal margin. *Australis* also has a tendency, not shown in *hinemoa* to become subtriangulate, and develop an anterior bluntly angled rostrum; this is more prominent still in *scalaris* Phil. *Hinemoa* has no sculpture beyond very fine concentric rugae; *australis* has in addition minute irregular radial scratches.

Length, 3.7 mm.; height, 2.9. mm. (the type is a large example; most shells are not much more than half this size).

Locality: Riverton, Southland, on seaweeds (type); a common Forsterian shell, but not reported north of Banks Peninsula. Chatham Is., several valves.

This is the "*Lasaea miliaris*" of Suter, not of Philippi. Suter's description is not very useful, and his figure is wretched.

Lasaea rossiana n. sp.

This is proposed for the Macquarie Island shell figured by Hedley in the *Mollusca Austral. Antarctic Exped.*, p. 33. Pl. 4, Figs. 42-44, 1916, and identified by him as *L. consanguinea* Smith. Kerguelan topotypes of that species, however, though closely similar in shape and general appearance are rather more elongate and distinctly more inequilateral, with less prominent beaks. *Consanguinea* has the appearance of a strong slope to the anterior end, as if it had been pulled from that direction. Moreover, the hinge of *rossiana,* well figured by Hedley, is altogether more massive and disproportionate to the size of the shell than that of *consanguinea,* which is much more like *australis* in this respect. Both *rossiana* and *consanguinea* have only fine concentric rugae for sculpture.

I have this species also from the Auckland Is., where it is rather common as a beach shell, and is probably what Suter recorded from there as *miliaris.*

Odhner's records of "*Lasaea minutissima*" (1924, p. 78) refer to a mixture of several species. Probably he had no true *minutissima* at all, his Stewart Is. shells will be *L. hinemoa,* and his subantarctic specimens mostly *rossiana.*

This species is not itself found at the Chathams, but I have named it here in order to describe by comparison a very similar form which does occur there.

Lasaea rossiana vexata n. subsp. (Figs. 41, 42).

Extremely close to the preceding, and at first sight identical. The posterior dorsal margin, however, as in *L. australis* drops down under the umbo to meet the anterior dorsal margin; in *rossiana* the line of the margin is more continuous. Translucent white, the hinge reddish; *rossiana* is brownish or red. Differs constantly in having fine wrinkles and punctures besides the concentric striae. It is practically on this last feature that I give the Chatham shells a distinct name; all the valves from there show it, while I have not been able to see it on any of a large series of *rossiana.* The shells are distinct from *L. neozelanica* Suter (which also has wrinkles) and are evidently the same as those Suter identified as *L. scalaris* Phil. (Suter, 1913, p. 928) from Taumaki and Stewart Islands—the latter species is a totally distinct form and does not occur in New Zealand.

Length, 2.4 mm.; height, 1.9 mm.

7 valves from the Chathams.

Family KELLIELLIDAE.

Cyamiomactra Bernard, 1897; *Bull. Mus. Hist. Nat.*, p. 311.

Cyamiomactra problematica Bernard, 1897. Suter, 1913, p. 899.
2 valves.

Family SPHAERIIDAE.

Sphaerium Scopoli, 1777; *Intra. ad Hist. Nat.*, p. 397.

Sphaerium novaezelandiae Deshayes, 1853. Suter, 1913, p. 934.
Reported by Suter on Professor Kirk's authority; it is not in my collections.

Family VENERIDAE.
Subfamily DOSINIINAE.

Phacosoma Jukes-Brown, 1912; *Proc. Mal. Soc.*, vol. 10, pt. 2.

Phacosoma maoriana (Oliver, 1923). *Proc. Mal. Soc.*, vol. 15, p. 188.
3 valves. The only other localities recorded for this species are Lyall Bay and Nelson, so that it seems to have come from the north, and its occurrence at the Chathams is of interest.

Phacosoma subrosea (Gray, 1853). Suter, 1913, p. 979.
Reported by Suter; no specimens have occurred to me. The record may be based on a specimen of *maoriana*, which is apparently not so rare at the Chathams as elsewhere, but it is quite likely that *subrosea* does occur there. *P. wanganuiensis* Marwick, an ancestral form, is reported from the Pliocene of Titirangi (Marwick, 1928, p. 469.

Kereia Marwick, 1927; *T.N.Z.I.*, vol. 57, p. 583.

Kereia greyi (Zittel, 1864). Suter, 1913, p. 980.
Recorded by Suter, but the record needs confirmation. A related new species (*K. chathamensis*) is described from the Oligocene by Marwick (1928, p. 469).

Subfamily VENERINAE.

Dosinula Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 470.

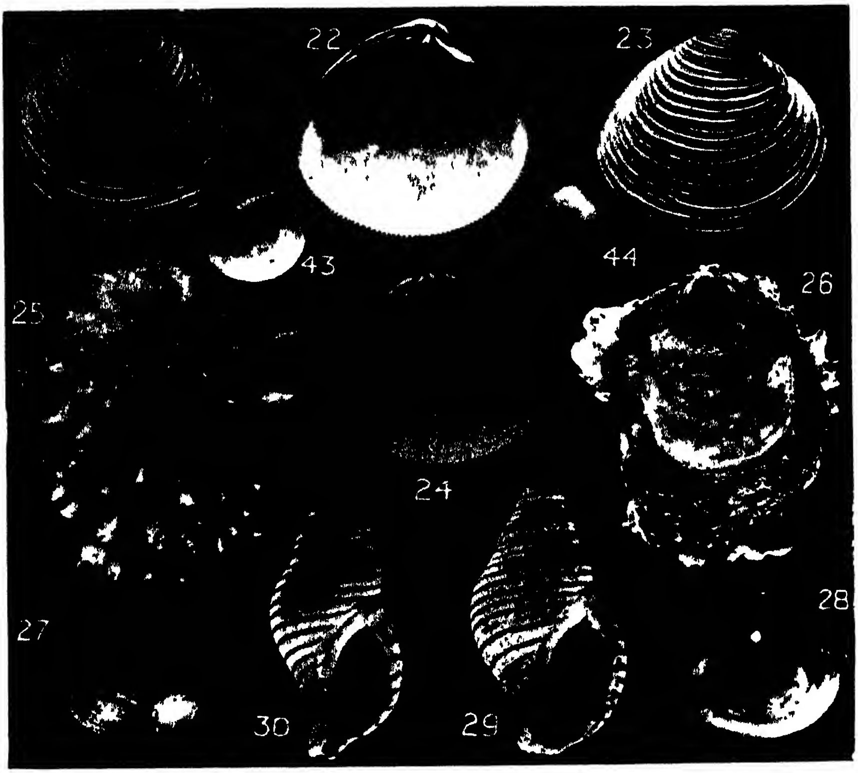
Dosinula zelandica (Gray, 1835). Suter, 1913, p. 985 (as *Cytherea oblonga*).
Reported by Suter; I have not seen it.

Tawera Marwick, 1927; *T.N.Z.I.*, vol. 57, p. 613.

Recent specimens of this genus in New Zealand are very difficult to classify. No agreement has yet been reached as to whether there is only one very variable species, *mesodesma* (Q. & G.), or several forms. *C. spissa* (Desh.) is allowed specific rank by some, not even varietal by others. The occurrence of still another apparently recognizable form in deep water off Otago Heads further complicates the problem. It may prove necessary to lump the lot together under one name, but I have adopted in the meantime a separation into three

FIGS. 1-2 —*Nucula dunedinensis* n. sp.: holotype × 15
FIGS. 3-4.—*Buccinulum pallidum* n. sp.: Chatham Is. shells. × 2.
FIG. 5.—*Buccinulum pallidum* n. sp.: holotype. × 2.
FIG. 6.—*Buccinulum lineum* (Martyn): Milford specimen. × 2.
FIG. 7.—*Evarnula marwicki* n. sp.: holotype. × 1½.
FIG. 8 —*Evarnula marwicki* n. sp.: paratype, Warrington. × 2.
FIG. 9.—*Evarnula marwicki* n. sp.: Chatham Is. specimen. × 2.
FIGS. 10-11.—*Euthrena bicincta* (Hutton): topotypes. × 2.

Figs 12 13 —*Austronoba mairtini* n sp holotype × 15
Fig 14 —*Eucominia nassoides* (Reeve) topotype × 2
Figs 15-16 —*Eucominia iredalei* n sp holotype (f 15) and paratype × 1½
Figs 17 18 —*Acominia adspersa nimia* n subsp holotype (f 17) and paratype × 1
Figs 19-20 —*Axymene traversi* (Hutton) topotypes × 4.



FIGS. 21-22-23-24.—*Tawera marionae* n. sp.: holotype. × 1
FIGS. 25-26.—*Ostrea charlottae* n. sp.: holotype × ½.
FIGS. 27-28.—*Lasaea hinemoa* n. sp.: holotype. × 6.
FIGS. 29-30.—*Chathamina characteristica* n. sp.: paratypes. ×
FIGS. 43-44.—*Nucula dunedinensis* n. sp: paratype × 5½.

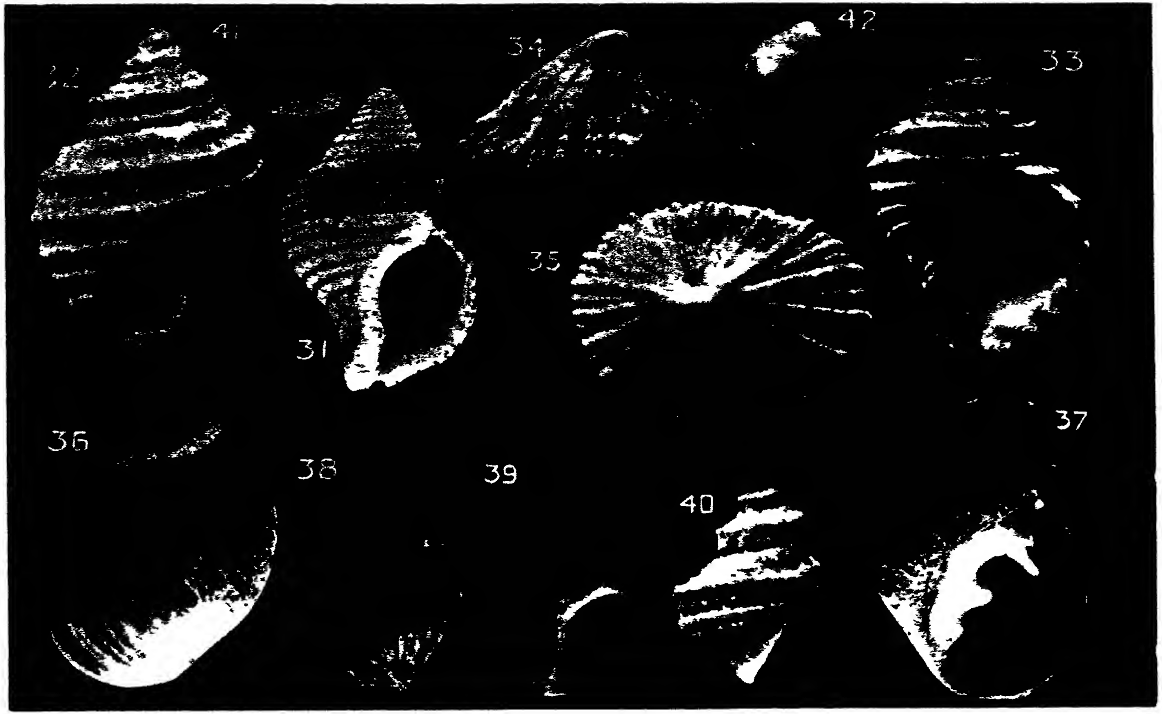
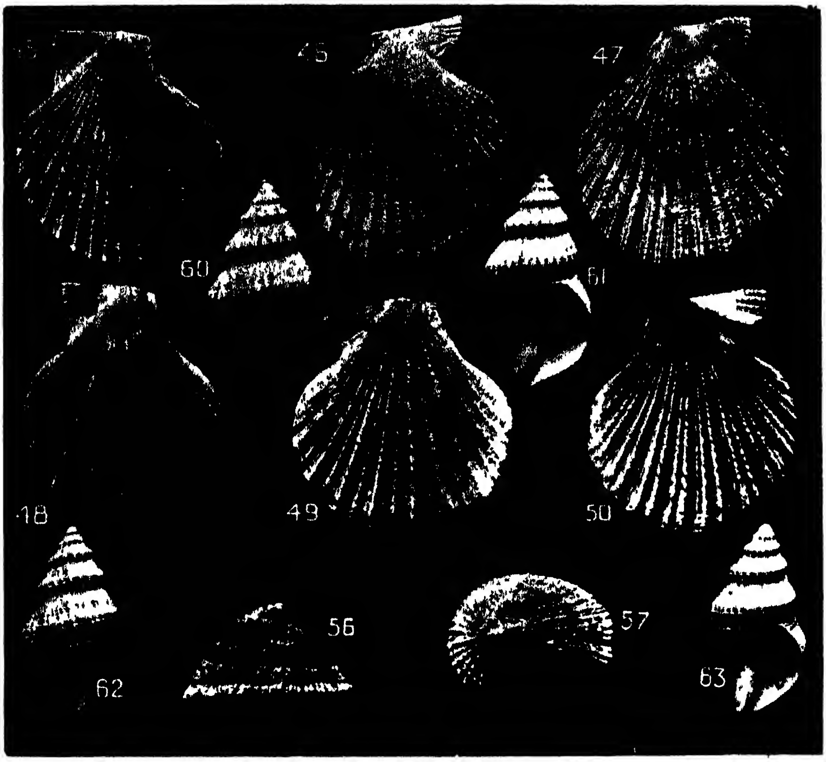


FIG. 31.—*Chathamina characteristica* n. sp.: holotype. × 1.
FIGS. 32-33.—*Lepsithais youngi* n. sp.: holotype × ¾.
FIGS. 34-35.—*Montfortula chathamensis* n. sp.: holotype. × 2½.
FIGS. 36-37.—*Marinula chathamensis* n. sp.: holotype. × 5½.
FIGS. 38-39.—*Paxula allani* n sp.: holotype. × 5½.
FIG. 40.—*Trichosirius inornatus chathamensis* n. subsp.: holotype. × 2½.
FIGS. 41-42.—*Lasaea rossiana vexata* n. sp and subsp.: holotype. × 5½



FIGS. 43-44.—See two plates back.
FIGS. 45-46-47-48.—*Chlamys dichrous* Suter: Chatham Is. specimens. × 1.
FIGS. 49-50.—*Chlamys celator* n. sp.: holotype. × ¾.
FIGS. 56-57.—*Emarginula striatula valentior* n. subsp.: holotype. × 1.
FIGS. 60-61-62-63.—*Austrofusus chathamensis* n. sp.: holotype (62, 63) and paratype. × ½.

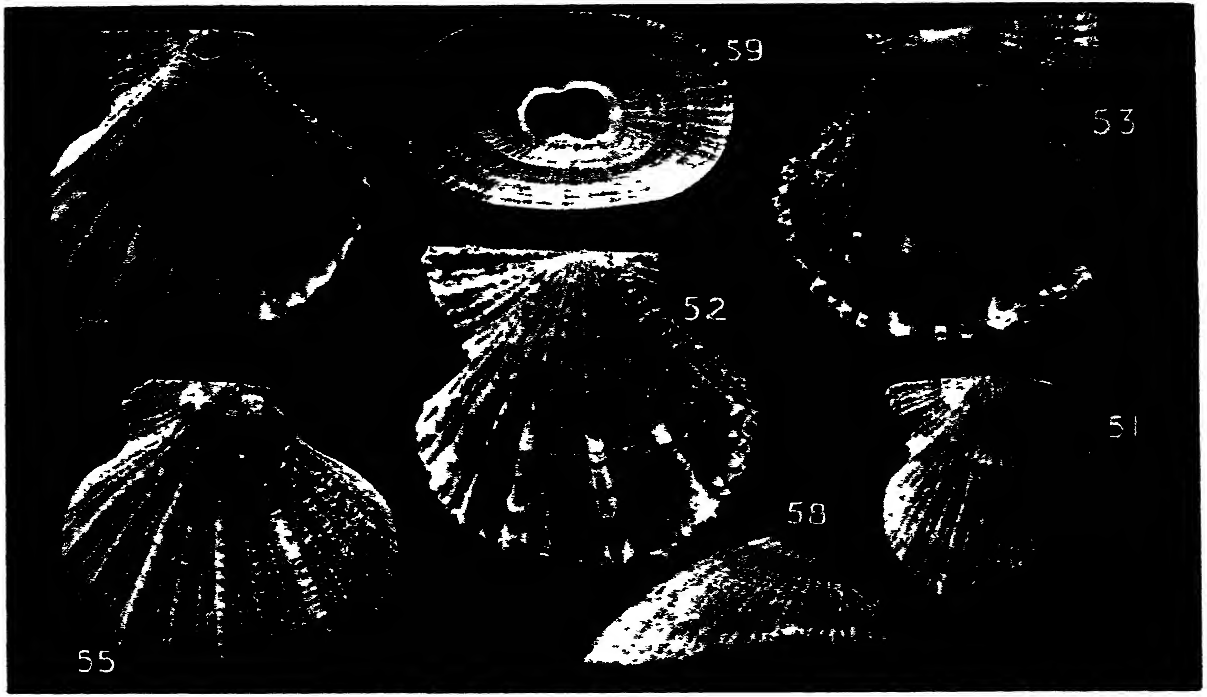


FIG. 51.—*Chlamys zelandiae* (Gray): Motutapu Is. specimen. × $\frac{3}{4}$
FIGS. 52-53.—*Chlamys suprasilis* n. sp.: holotype. × 1.
FIG. 54.—*Chlamys suprasilis* n. sp.: Taieri Beach specimen. × $\frac{3}{4}$.
FIG. 55.—*Chlamys suprasilis* n. sp.: Chatham Is. specimen. × $\frac{3}{4}$.
FIG. 58.—*Emarginula striatula* Q. & G.: Auckland specimen. × 2.
FIG. 59.—*Monodilepas skinneri* n. sp.: holotype. × $1\frac{1}{2}$.

N.B.—The magnifications on this plate are greater than indicated

nominal "species," all of which occur at the Chathams. This particular matter will probably always remain a personal one, and its solution dependent on the inclinations of the worker; I am myself very reluctant to merge names so long as there is any possibility of their being useful to cover distinguishable forms. The two mid-Pliocene species of this group, *T. subsulcata* (Suter) and *T. marthae* Marwick (the latter from the Chathams, see *T.N.Z.I.*, vol. 58, p. 471, 1928), are easily separable from the Recent forms by their long ligament pit, equal to or greater than half the length from beaks to posterior extremity in the fossils much less than half the distance in the living shells.

Key to the Recent forms:—

(a) Beaks prominent, inflated and largely overtopping hinge; lunule wide and rather short, concave; shell subtriangular, very gibbous; posterior dorsal area swollen, not hidden from the front by any expansion of the margins; 9-11 concentric ribs per cm. in centre of valve; hinge solid and teeth rather long. .... *T. spissa.*

(b) Beaks inconspicuous; lunule narrow and long, distinctly convex, and usually a little raised; shell subtriangularly ovate, rather compressed; posterior dorsal area inconspicuous, hidden from the front by the high, subangled, slightly winged and expanded margin; 10-10½ concentric ribs per cm. in centre of valve; hinge rather weak and teeth short .... *T. marionae.*

(c) Beaks usually inconspicuous; lunule narrow and long, lightly convex, and usually but little raised; shell elongate oval, moderately inflated; posterior dorsal area usually weak, but never hidden by expanded margins; 13-15 concentric ribs per cm. in centre of valve, radial sculpture practically obsolete (radial scratches and grooves are usually rather prominent in the other two forms); hinge narrow, teeth short. .... *T. mesodesma.*

Tawera marionae n. sp. (Figs. 21, 22, 23, 24).

Differs from *mesodesma* (Q. & G.) in larger size; relatively higher, less elongate, more trigonally ovate shell; much coarser sculpture, the concentric ribs (10-10½ per cm. in centre of valve) thick, adpressed, sharply edged behind and flattened down in front, interstices half to whole width of ribs, radial sculpture generally well marked as irregular scratches and grooves, more prominent posteriorly. The concentric ribs very often do not exactly follow the growth lines and are truncated by them towards the anterior and posterior sides; this feature is often very marked between one rest period and another, the ribs taking quite different directions and producing a strikingly uneven effect; the ribs sometimes anastomose at the anterior end and at both ends become lamellose near the margins; the coarse sculpture continues almost up to the prodissoconch. Beaks not quite at anterior third low and inconspicuous. Anterior margin sloping at about 40 degrees only a little interrupted by the lightly convex lunule. Posterior margin with a bulge just past the end of the hinge where it is expanded and forms a slight wing which from the front hides almost all the escutcheon and

posterior dorsal area. Ligament pit less than half distance from beaks to posterior end. Generally much darker coloured than *mesodesma*, greyish-brown, very rarely with zigzag colour stripes, usually completely white inside, but sometimes with small patches of violet. Hinge narrow, the teeth rather low and widely divergent, but well forward; right anterior cardinal sublaminar, nearly parallel to margin; median rather stout, triangularly elevated, sloping well forwards, a deep narrow groove near its hinder edge; posterior not large, pointing at pallial sinus, bifid: left anterior strong, thin and sharp under umbo, much stouter below, not subparallel to margin; median small, moderately thick, bifid; posterior very small, lamellar, not reaching the curve in the hinge line.

Height, 28 mm.; length, 33 mm.; width (2 valves), 16 mm.

Locality: Off Otago Heads in 60 fathoms (type and many others) and 20 fathoms. Chatham Is., two complete specimens and three valves.

Tawera spissa (Desh., 1835). Suter, 1913, p. 991 (as *C. crassa*).
One typical specimen.

Tawera mesodesma (Q. & G.). Suter, 1913, p. 991.
Two valves, one with extremely fine concentric sculpture.

Austrovenus Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 470.

Austrovenus stuchburyi (Gray, 1828). Suter, 1913, p. 987.
5 specimens. I have been told that in the Great Lagoon at the Chatham Islands this species is very stunted, owing to the brackish water habitat, and develops only a very thin and fragile shell. Unfortunately no such specimens were collected for me.

Subfamily PAPHIINAE nov.

This group, usually called Tapetinae, seems more homogeneous and distinct than any other major group of the Venerids. In New Zealand it includes the following genera:—*Paphia* Bolten, 1798 (subgenus *Callistotapes* Sacco, 1900), *Gomphina* Moerch, 1853 (subgenus *Gomphinella* Marwick, 1927), *Protothaca* Dall, 1902 (subgenus *Tuangia* Marwick, 1927), *Notopaphia* Oliver, 1923, *Eumarcia* Iredale, 1925 (with subgenus *Atamarcia* Marwick, 1927), *Paphirus* Finlay, 1927, *Irona* Finlay, 1927, and *Cyclorismina* Marwick, 1927. If a group name is used, it must be derived from *Paphia* rather than from *Tapes* Megerle, 1811, the former having thirteen years priority.

Tuangia Marwick, 1927; *T.N.Z.I.*, vol. 57, p. 623.

Tuangia crassicosta (Desh., 1835). Suter, 1913, p. 996 (as *P. costata*)
1 valve.

Paphirus Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 471.

Paphirus largillierti (Phil., 1847). Suter, 1913, p. 995 (as *P. intermedia*).
4 valves. Common at Titirangi (Pliocene).

Notirus nom. nov. for *Irona* Finlay, 1926 (*T.N.Z.I.*, vol. 57, p. 471), *non Ironus* Bastian, 1865 (*Trans. Linn. Soc. Lond.*, vol. 25. p. 103).

Notirus reflexus (Gray, 1843). Suter, 1913, p. 998.
Not uncommon.

Family TELLINIDAE.

Macomona Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 466.

Macomona liliana (Iredale, 1915). Suter, 1913, p. 948 (as *T. deltoidalis*).

There is a specimen of this shell reputed to have come from the Chatham Islands in the Otago University Museum.

Zearcopagia Finlay, 1926; *T.N.Z.I.*, vol. 57, p. 466.

Zearcopagia disculus (Desh., 1855). Suter, 1913, p. 951.
Rather common.

Family GARIDAE.

Gari Schumacher, 1817; *Essai. Nouv. Syst.*, p. 44.

Gari lineolata (Gray, 1835). Suter, 1913, p. 1002.

Not uncommon. The only species reported from the Tertiary by Marwick (1928, p. 472) is *G. stangeri* (Gray), which is common in the Pliocene.

Soletellina Blainville, 1824; *Dict. Sci. Nat.*, vol. 32, p. 350.

Soletellina sp cf. *siliqua* Reeve.

8 valves, all more or less worn. They seem to differ from my northern and southern specimens of *siliqua* in larger size and more uniformly elongate oval shape, the dorsal and basal margins being subparallel, and the posterior end not narrowly acuminate; the beaks are almost median; a characteristic feature is that the anterior dorsal margin and the nymph form a continuous, almost straight line. I have seen no shells quite the same from the mainland, and a new species is possibly represented, for the Chatham shells differ quite as much from both *nitida* and *siliqua* as these two from each other. As, however, species of this genus are somewhat variable, the specific characters of neither *nitida* nor *siliqua* being so well defined that they are easily separable, and as there are already other names (e.g., *S. nitens* Tryon) proposed for New Zealand specimens, so that ample material is necessary for a revision of the species, it is better to withhold nomination at present.

Family MACTRIDAE.

Longimactra new genus. Type: *Mactra elongata* Q. & G.

Longimactra elongata (Q. & G., 1835). Suter, 1913, p. 965.

One valve. This species is not a *Mactra*, as Suter has placed it, since it has no shelly ridge separating the ligament from the chondrophore. Woodring (Miocene Molluscs from Bowden, Jamaica, *Carn. Inst., Pub. No. 366*, p. 184, 1925) remarks that, "The absence of a ridge between the ligament area and chondrophore is the most char-

acteristic feature of the genus *Spisula.*" Hutton's final location of this species in *Hemimactra* (*P.L.S., N.S.W.*, vol. 9, p. 518) was therefore nearer the truth. The species, however, is not much like any other *Spisula,* and has been variously located in *Mactra, Spisula, Standella, Hemimactra,* and *Mulinia.* The characteristic very elongate form, colour scheme of spots and dashes, deep sinus, huge muscle scars, and horizontally extended hinge are best expressed by locating the form in a new genus. Two further new genera seem to be required for New Zealand Mactroids:—*Scalpomactra* Finlay, 1928 (in Marwick, 1928, p. 432), proposed for *Mactra scalpellum* Reeve, and MAORIMACTRA n. gen. for *Mactra ordinaria* Smith.; both these have a long line of Tertiary ancestors in New Zealand. *Scalpomactra,* like *Longimactra,* has been wrongly referred to the Mactrinae; it is a Spisuloid genus, the ligament being extremely minute and difficult to discern but certainly not separated off by any shelly process; the differences in hinge and growth stages prevent the reference of *scalpellum* to *Longimactra* with which it superficially agrees in elongate shell. *Maorimactra,* on the other hand has been just as erroneously associated with *Spisula,* it has a prominent shelly plate separating the ligament from the resilium and is truly Mactroid, even as Smith originally thought; the very small size, characteristic *Corbula*-like contour, and hinge are the most decided generic features.

Scalpomactra Finlay, 1928. Type: *Mactra scalpellum* Reeve.

Scalpomactra scalpellum (Reeve, 1854). Suter, 1913, p. 963.

3 large and perfect examples taken from fishes' stomachs. These show distinctly the curious shape of the resilium; a stoutish, obliquely placed, isosceles triangle below, produced above into a long narrow spike, curved to the front, to the top of this the minute ligament is united for nearly all its length. The lateral teeth are not grooved internally. Marwick obtained fragments of this species from the Pliocene beds (1928, p. 469).

Family AMPHIDESMATIDAE.

Taria Gray, 1853: *Ann. Mag. Nat. Hist.*, ser. 2, vol. 11, p. 44.

Taria subtriangulata (Wood, 1828). Finlay, 1926. p. 467.

One valve. Oliver (1923, p. 187) states that shells from the Chathams "are almost invariably of the broad-angled thin form," and that " the angle formed by the dorsal and posterior sides varies through several degrees." I have not a range of specimens to determine the amount of variability of the Chathams, but the single valve sent me is distinctly of the northern type, solid, elongate, with very short and bicarinate posterior side, and thus referable to *subtriangulata* (Wood). It would be very interesting if the broad, triangularly ovate, unicarinate *forsteriana* Finlay were to occur at the Chathams also as this would prove the two forms absolutely distinct, instead of only regional relatives. Till evidence is forthcoming, however, it seems best to admit only *subtriangulata* to the Chatham

fauna. Marwick (*T.N.Z.I.*, vol. 58, p. 468, 1928) has compared his *Amphidesma porrectum* (Pliocene, Titirangi) with *subtriangulatum.*

Paphies Lesson, 1831; *Zool. Voy. "Coquille,"* vol. 2, pt. 1, p. 424.

Paphies australis (Gmelin, 1791). Suter, 1913, p. 960.

Reported by Suter; no specimens were sent me.

Family CORBULIDAE.

Corbula Bruguière, 1797; *Ency. Meth.* (*Tabl. Vers.*), Pl. 230.

Corbula haastiana Hutton, 1878. Suter, 1913, p. 1011.

One perfect specimen, identified by Suter (1913, p. 1008) as *Corbula gibba* (Olivi). In spite of Suter's declarations to the contrary, I believe that the sole specimen of his *"gibba"* is the same species as the unique right valve of *haastiana* Hutton, which I think is an abnormal one. Some accident or disease has caused a deep pit to be formed under the umbo, and the hinge is much distorted in consequence, the cardinal tooth being absent or broken away. This has also affected the growth of the shell, the anterior end being considerably produced downwards, while the posterior truncation is very short, the beaks being actually nearer the posterior end. Otherwise, in sculpture, epidermis, general appearance, etc., the two shells are identical and specifically are very close to the Tertiary forms grouped around *C. pumila* Hutton (see Suter, *N.Z.G.S. Pal. Bull. No. 3*, p. 60, 1915). As a species, *haastiana* could easily be a direct descendant of *pumila.* The Chatham Is. specimen, on which the record of *gibba* is based, does not agree with any of the figures of this European form given by Forbes and Hanley, H. & A. Adams, Reeve, Cossmann, etc., being too elongate, and the right valve apparently different in shape and sculpture. I have already (*T.N.Z.I.*, vol. 57, p. 472, 1926) rejected this record of *gibba,* on the assumption that if Suter's shell was really *gibba* it was not Neozelanic, while if it was from New Zealand it was not *C. gibba*; but now that I have examined and carefully compared the actual specimens of *"gibba"* and *haastiana,* I think that the locality of the former is quite likely to be correct, especially when one bears in mind the previous existence here of closely allied Tertiary forms. The state of preservation of the specimen, which is not at all worn, and has the dried animal inside, is rather against its being a Chatham beach shell, but it may have come from a fish stomach. On the whole, therefore, it seems best to regard it at present as a more normal development of the species *haastiana* Hutton, and descended from the Tertiary *pumila* Hutton.

Aloidis Megerle, 1811; *Ges. Nat. Fr. Berlin,* Mag. 5, No. 1, p. 67.

Aloidis zelandica Q. & G., 1835. Suter, 1913, p. 1010.

2 valves. A related species from the Tertiary of Whenuataru Peninsula is *C. howesi* Marwick (*T.N.Z.I.*, vol. 58, p. 472, 1928).

Family Saxicavidae.

Saxicava Bellevue, 1802; *Journ. Phys.*, vol. 54, p. 5.

Saxicava australis (Lamk., 1818). Suter, 1913, p. 1012 (as *S. arctica*).
8 valves.

Panope Menard, 1807; *Mem. Nouv. Genre Coq. Biv.*, p. 31.

Panope zelandica (Q. & G., 1835). Suter, 1913, p. 1013.
1 valve.

The new generic and specific names proposed in this paper are as follows:—

Montfortula chathamensis n. sp.
Emarginula striatula valentior n. subsp.
Monodilepas skinneri n. sp.
Austronoba martini n. sp.
Lyroseila n. gen. for *Seila chathamensis* Suter.
Trichosirius inornatus chathamensis n. subsp.
Xenogalea collactea n. sp.
Xenogalea powelli n. sp.
Uberella n. gen. for *Natica vitrea* Hutton.
Zenepos n. subgen. for *Daphnella totolirata* Suter.
**Ellicea* Finlay for *Siphonalia orbita* Hutton.
Chathamina n. subgen. for *Tritonidea fuscozonata* Suter.
Chathamina characteristica n. sp.
Buccinulum pallidum n. sp.
Evarnula marwicki n. sp.
Austrofusus chathamensis n. sp.
Acominia adspersa nimia n. subsp.
Eucominia iredalei n. sp.
Paxula allani n. sp.
Lepsithais n. gen. for *Polytropa squamata* Hutton.
Lepsithais youngi n. sp.
Marinula chathamensis n. sp.
Gumina n. gen. for *Odostomia dolichostoma* Suter.
Eulima archeyi n. sp.
Nucula dunedinensis n. sp.
Ostrea charlottae n. sp.
Ostrea hefferdi n. sp.
Ostrea fococarens nom. nov. for *O. corrugata* Hutton, *non* Brocchi.
**Notostrea* Finlay for *Ostrea subdentata* Suter.
**Notostrea lubra* Finlay for *Gryphaea tarda* Tate, *non* Hutton.
Lopha pahiensis n. sp. for *Ostrea gudexi* M. & M., *non* Suter.
Chlamys celator n. sp.
Chlamys suprasilis n. sp.
Lasaea hinemoa n. sp.
Lasaea rossiana n. sp.
Lasaea rossiana vexata n. subsp.

*To avoid priority confusion these four new names have already been formally proposed in a preliminary note to Dr. Marwick's paper on the Chatham Is. Tertiary Mollusca (*T.N.Z.I.*, vol. 58, p. 432, 1928), but are included here for sake of completeness.

Tawera marionae n. sp.
Notirus nom. nov. for *Irona* Finlay, *non Ironus* Bastian.
Longimactra n. gen. for *Mactra elongata* Q. & G.
**Scalpomactra* Finlay for *Mactra scalpellum* Reeve.
Maorimactra n. gen. for *Mactra ordinaria* Smith.

The following new Family or Subfamily names are also indicated:—

Family TALOPHIDAE nov.
Family BEMBICIIDAE nov., to replace Risellidae.
Family BUCCINULIDAE nov.
Subfamily SIPHONALIINAE nov.
Subfamily PAPHIINAE nov., to replace Tapetinae.

Of the 202 species now recorded from the Chathams, 112 are more or less universally distributed throughout the Maorian Sub-Region, 31 are of distinct Forsterian affinities, 28 have closer allies in the Cookian region than elsewhere, and 31 seem at present to be endemic. All forms whose distribution is not well known, or regarding which I have any doubt, have been placed amongst the 112 in making this census, so that the other figures can be taken as fairly representing the proportionate influence of other regions on the molluscan fauna of the Chathams. The Forsterian influence is, however, more predominant than the actual figures show; of the 28 North Island forms, only four (*Triviella memorata, Macrozafra subabnormis saxatilis, Gumina dolichostoma,* and *Lopha glomerata*) are really restricted regional forms, while the 31 species of South Island affinities include many highly characteristic Forsterian shells, such as *Thoristella chathamensis, Maurea cunninghami pagoda, Ubercella vitrea, Buccinulum pallidum, Evarnula marwicki, Austrofusus glans agrestior, Nucula dunedinensis, Chlamys celator, C. suprasilis, Gaimardia forsteriana, Costokidderia costata, Mysella unidentata, Lasaea hinemoa,* and *L. rossiana vexata.* Of the 31 endemic forms, the most notable and characteristic are: *Plaxiphora schauinslandi, Monodilepas skinneri, Margarella fulminata, Chathamina characteristica, Euthrena bicincta, Austrofusus chathamensis, Eucominia iredalei, Paxula allani,* and *Lepsithais youngi.* It is worthy of note that many of the Chatham shells are larger, stouter, and of heavier build than their Mainland relatives, e.g., *Acominia adspersa nimia, Monodilepas skinneri, Euthrena* spp., *Eucominia iredalei, Axymene traversi, Lepsithais youngi,* etc.; the reason for this is obscure, unless it has to do with the prevalent heavy weather and stormy seas in that region. It is also noteworthy that no Volutes seem to occur in either the Recent or the Pliocene fauna, though one (*Waihaoia (Pachymelon) renwicki* Marwick, see *T.N.Z.I.*, vol. 58, p. 488, 1928) is found in the Oligocene beds there; the apparent absence of *Alcithoe arabica* and *gracilis* is remarkable. Similarly, in the family Buccinulidae while the subfamily Buccinulinae is strongly represented in the Recent fauna by four genera (*Buccinulum, Chathamina, Evarnula,* and *Euthrena*) with six species, four of them being amongst the commonest Chatham shells, it is wanting in the Tertiary; conversely the subfamily Siphonaliinae, represented in the Oligocene by *Verconella asper* Marw. and *Pittella valida* Marw. (*l.c.*, pp. 485, 486),

has no Recent or Pliocene members, the absence of *Verconella adusta* and *mandarina* being again remarkable; but most of these are shore shells, which may account for their absence. The whole Recent Molluscan fauna of the Chathams, however, seems independent of the Tertiary faunas; the most characteristic shells now inhabiting its shores are not represented in the Pliocene beds (which are of shallow water facies, and therefore the most likely to contain these forms, if present), the only endemic Recent species which are also found fossil there being *Mylitella pinguis* and *Zegalerus crater.* Although a few forms (*Venericardia purpurata, Taria subtriangulata, Tawera marionae, Eucominia iredalei,* and *Zeatrophon ambiguus*) have more or less closely allied representatives (*V. martini, T. porrecta, T. marthae, E. ellisoni,* and *Z. mutabilis,* all of Marwick, see *T.N.Z.I.*, vol. 58) in the Pliocene fauna of Titirangi, there is little reason for believing the lineage direct; the ancestors of the Recent species are more probably Mainland fossils — in several cases this is demonstrably so. The converse is not quite so evident; many of the Pliocene species are, of course, identical with the Recent forms, and there is a general generic agreement (*Eumarcia plana* and *Glycimeris waipipiensis* are unrepresented in the Recent fauna, but this is also the case on the mainland, where these species again occur in Pliocene beds of the same horizon); but even if it is admitted that the Pliocene fauna may have lived on in the same locality, it is plain that the Quaternary period has witnessed notable additions, both generic and specific.

Consideration of all the above facts leads one inevitably to believe that the Recent Molluscan fauna of the Chatham Islands is *not* a remnant or evolution of the Tertiary faunas found there, but a re-population from the Mainland, in post-Pliocene times, but yet long enough ago for charasteristic regional species and subspecies to have evolved. Every one of the endemic species can be regarded as lately evolved from a Mainland form or its direct ancestor; the two genera *Montfortula* and *Magilina* which are now first reported as constituents of the Maorian Recent fauna are certain to be discovered also on the Mainland. The case of *Austrofusus chathamensis* may be considered in this connection. It is now apparently restricted to the Chathams, but I have noted (*antea*) that it seems to occur fossil on the Mainland in the Castlecliff Upper Pliocene beds, where the genus shows great variation and seems to be evolving distinct forms. These apparently reached the Chathams after the Pliocene (no *Austrofusus* has so far occurred in any of the Chatham Tertiary beds) and the *chathamensis* form alone survived in that locality, while the *glans* form developed solely in the Cookian region, and gave rise to its Forsterian representative *glans agrestior*; this apparently was later also carried to the Chathams, from the South.

A census of the present fauna seems to indicate that the active factor in this re-population has been ocean currents, acting from both North and South, but predominantly from the latter. The great cold-water current that sweeps south of Australia, over the Tasman Sea, round the southern extremity of New Zealand and Stewart Island, and up the east coast, finds the Chathams then directly in its path, and must be responsible for the larger part of its present

molluscan fauna. Most of the remainder has probably been brought by that branch of the warmer Notonectian current which, after sweeping down the east coast of Australia and also across the Tasman Sea, strikes up the west coast of the South Island and then divides somewhere in the North Cookian region, the branch that concerns us then returning south through Cook Strait, and disappearing in the direction of the Chathams. An insignificant residue may have remained or evolved from the Pliocene fauna of the Chathams.

A complete list of the endemic shells (so far as yet known) is as follows. Species whose derivation seems evidently from the north are marked "N," those from the south "S"; the approximate equality in number of these two still further indicates the heterogeneous nature of the Chatham Island Recent molluscan fauna:—

Maorichiton schauinslandi (Thiele). S.
Scissurella n. sp. S.
Sinezona subantarctica var. S.
Tugali suteri (Thiele). N.
Montfortula chathamensis Finlay. N.
Monodilepas skinneri Finlay. S.
Margarella fulminata (Huton). S.
Liotella n. sp.
Radiacmea rubiginosa (Hutton)
Cellana chathamensis (Pils.).
Estea n. sp. aff. *minor* (Suter). S (?).
Estea sp. cf. *subfusca* (Suter). S.
Austronoba martini Finlay. N.
Trichosirius chathamensis Finlay.
Zegalerus crater Finlay. N (?).
Magilina n. sp.
Chathamina characteristica Finlay. N.
Euthrena bicincta (Hutton). S (?).
Austrofusus chathamensis Finlay. N.
Acominia nimia Finlay. N.
Eucominia iredalei Finlay. S.
Paxula allani Finlay. S.
Axymene traversi (Hutton).
Lepsithais youngi Finlay. S.
Marinula chathamensis Finlay.
Eulima archeyi Finlay. N.
Tethys n. sp. (?). N.
Modiolus fluviatilis (Hutton).
Myllitella pinguis Marwick. N.
Soletellina n. sp. (?).

30 species; 10 of northern affinities, 11 of southern, 9 doubtful.

This list of endemic forms, heterogeneous in origin though they may be, is sufficient to give the Chatham Islands the status of a distinct faunal region. Accordingly, I have elsewhere (*Verbeek Mem.* Birthday Vol., p. 168, 1925) proposed for this region the name Moriorian Province, as a division of the Maorian Sub-Region. This is also geologically (*vide* Allan, *N.Z. Journ. Sci. and Tech.*, vol. 7, pp. 290-294, 1925) necessary, while the palaeontological evidence (*vide* Marwick, *T.N.Z.I.*, vol. 58, pp. 432-506) of the peculiarity of the Tertiary faunas is further justification.

The following forms were taken by Mr. R. S. Allan from the stomachs of cod during the fishing season:—

Monodilepas skinneri, Haliotis australis, Cominella maculosa, Chlamys celator, C. suprasilis, C. radiatus, C. dichrous, Pallium convexus, Limatula maoria, and *Paphies australis.*

In conclusion, I wish to thank the Otago and Canterbury Institutes for the opportunity of studying this interesting fauna, and

especially all those members of the expedition who so kindly made this possible by giving up valuable time from their own labours to collect the shells for me. To Messrs. Young and Allan, and Dr. Marwick, I am especially indebted for information and observations which, owing to my own inability to join the party, I would otherwise have lacked entirely; any merits the present account may have are due to the efforts and forethought of these and other members of the Expedition.

LIST OF MAIN REFERENCES.

FINLAY, H. J., 1925. Some Modern Conceptions Applied to the Study of the Cainozoic Mollusca of New Zealand. *Verbeek Mem. Birthday Vol.*, pp. 161-172.

—— 1926. A Further Commentary on New Zealand Molluscan Systematics. *Trans. N.Z. Inst.*, vol. 57, pp. 320-485.

HEDLEY, C., 1916. Mollusca. *Sci. Reps. Australas. Antarct. Exped.*, ser. C, vol. 4, pt. 1, pp. 1-80.

IREDALE, T., 1915. A Commentary on Suter's Manual of the New Zealand Mollusca. *Trans. N.Z. Inst.*, vol. 47, pp. 417-497.

—— 1924. Results from Roy Bell's Molluscan Collections. *Proc. Linn. Soc. N.S.W.*, vol. 47, pt. 3, pp. 179-278.

MARWICK, J., 1928. The Tertiary Mollusca of the Chatham Islands, including a Generic Revision of the New Zealand Pectinidae. *Trans. N.Z. Inst.*, vol. 58, pp. 432-506.

OLIVER, W. R. B., 1915. The Mollusca of the Kermadec Islands, *Trans. N.Z. Inst.*, vol. 47, pp. 509-568.

SUTER, H., 1913. Manual of the New Zealand Mollusca, with (1915) Atlas of Plates. Wellington, Govt. Printer.

The Flora of the Waipaoa Series (Later Pliocene) of New Zealand.

By W. R. B. OLIVER, M.Sc., F.L.S., F.N.Z., Inst.

[*Read before the Wellington Philosophical Society, 24th October, 1926; received by Editor, 9th March, 1928; 10th August, 1928.*]

PLATES 44-45.

Material: The plants described in the following account consist of two small collections made in the same locality, namely, near Ormond, in the Poverty Bay District, New Zealand. The first was made by Mr. H. Hill, about 1910, the second by Mr. M. Ongley, of the New Zealand Geological Survey, during 1914-16. Both collections are the property of the Geological Survey, and were placed in the hands of the author for identification by the late Director, Mr. P. G. Morgan. The specimens are at present deposited in the Dominion Museum, Wellington. The material consists of carbonized remains and impressions of leaves and in some cases fruits on a fine-grained volcanic silt. Many of the specimens were too fragmentary for identification, but from those sufficiently well preserved, thirty-one species have been described. Associated with the leaves were several impressions of fish skeletons and fins. In size they agree with the Recent fresh-water fish *Gobiomorphus*.

Geological Horizon: The fossils were found in a finely-laminated pumiceous silt which outcrops along an escarpment for about half a mile. Impressions of leaves occurred here and there along the western end, but only in places were the leaves found in any quantity. The author visited the locality in 1926, but found only a few leaf remains.

The beds lie in a Tertiary valley, and with others of similar lithological character and stratigraphical position are classed as the Waipaoa Series.

Age. (1) Palaeozoological. The information under this head has been kindly supplied me by Dr. J. Marwick, Palaeontologist to the New Zealand Geological Survey Department. In their report on the Geology of the Gisborne and Whatatutu Subdivision, Henderson and Ongley give a list of mollusca supposed to have been found in beds of the Waipaoa Series in the Kaiti Hills and said to be of older Pleistocene age. Dr. Marwick informs me that the authenticity of the collection is challenged, that it is very like Castlecliff material, and that recent search has failed to find a similar fauna in the locality. Further, it is of later Pliocene age. In the Kaiti Hills Dr. Marwick could find only impressions of *Chione stutchburyi* (Gray).

The only other locality in which beds of the Waipaoa Series contain marine fossils is a hill east of the junction of the Oweka and Maddox streams. Here the following mollusca were collected by the officers of the Geological Survey:—*Nucula hartvigiana* Pfr.,

Ostrea angasi Sow., *Dosinia grayi* Zitt., *Chione stutchburyi* (Gray), *Bassina Yatei* (Gray), *Cominella* aff. *adspersa* Brug., *Acteon sulcatus* (Hutt.). The presence of *Acteon sulcatus* gives evidence of the beds being of Castlecliffian age (Later Pliocene).

(2) Palaeobotanical. The evidence of the plant-fossils as to the age of the beds supports that of the mollusca, for although seventeen of the thirty-one species have been described as not now existing, thirteen of them are referred to existing New Zealand genera, and in most cases there is a close relationship to New Zealand species. However, the fact that a considerable proportion of the species including some of extra New Zealand affinities are extinct, would indicate an age not younger than later Pliocene.

Relationships with the early Tertiary are shown by the following lists in which certain plants of the Waipaoa Series are compared with species described by Ettingshausen as early Tertiary:—

Waipaoa Series.	Early Tertiary.
Lomaria proceroides.	*Lomariopsis dunstanensis.*
Goniopteris pennigera.	*Aspidium tertiaro-zelandicum.*
Typha angustifolia.	*Zamites* sp.
Rhopalostylis sapida.	*Seaforthia zelandica.*
Beilschmiedia ovata.	*Daphnophyllum australe.*
Apocynophyllum novae zelandiae.	*A. Mackinlayi.*
Ceratopetalum pacificum.	*C. Gilesii.*

Comparisons may be made with the Cromer Forest Bed, England, usually considered as of late Pliocene age, and in which none of the 150 species are extinct, and with the Potosi flora of Bolivia described by Berry (*Proc. U.S. Nat. Mus.*, vol. 54, p. 113, 1919) in which 54 of the 66 definitely-determined species are closely related to existing species. Berry determined this flora as of later Pliocene age. The proportion of extinct forms in the Waipaoa flora is similar to that of the Potosi flora and greater than that of the Cromer Forest flora.

Climate: The climate indicated by the flora of the Waipaoa Series is warm temperate, possibly slightly warmer than that at present found in north New Zealand. The following genera show a distinctly warm facies:—*Platycerium, Rhopolostylis, Litsaea, Beilschmiedia, Knightia,* and *Carmichaelia.* The presence of *Nothofagus* does not necessarily indicate a cold climate as *N. fusca* occurs living in the north of New Zealand.

Plant Formations: With one or two exceptions the flora of the Waipaoa Series represents a rain forest. In fact, with the exception of three species, all are such as would be expected in a forest. Three species, namely, *Typha angustifolia, Pteridium esculentum,* and *Leptospermum pliocenicum,* indicate a more open type of vegetation, such as a lake-shore which would provide the requisite conditions for the preservation of the fossil flora, and perhaps some scrub which might grow in its vicinity.

Relationships: Of the thirty-one species herein described fourteen have been referred to Recent New Zealand species, thirteen

have been attributed to Recent New Zealand genera, two to extra-New Zealand genera (*Platycerium, Ceratopetalum*), and two to a genus (*Apocynophyllum*) of which the New Zealand species are all extinct. The flora is thus in the main related to the Recent flora of New Zealand, the only extraneous element being of Australian or Malayan affinity, for *Ceratopetalum* is an Australian genus, and *Platycerium* a common tropical genus occurring widely in Australia. The genera include such distinctive New Zealand plants as *Rhopalostylis, Knightia, Carmichaelia, Melicytus, Nothopanax, Pennantia, Hebe* and *Coprosma*. Relationships are shown with South America (*Coriaria*), Australia, Malaya and the Pacific Islands, but not to any extent different to those of the Recent flora. This late Pliocene flora is thus to be considered as of the same origin as the Recent New Zealand flora.

Literature: The fossil flora of the Waipaoa Series is referred to by Hill (*Trans. N.Z. Inst.*, vol. 20, p. 300, 1888) who states that he found forty-six species of plants in the Poverty Bay pumice-beds, and again by the same author (*Trans. N.Z. Inst.*, vol. 21, p. 320, 1889) when describing the occurrence of moa feathers in the same beds as the leaves. Morgan, in Henderson and Ongley's report (*N.Z. Geol. Surv. Bull.*, No. 21, p. 50, 1920) gives a brief account of the flora and concludes that it is of Pliocene age.

Dryopteris novae zelandiae Oliver n. sp. (Fig. 1).

Impression of portion of pinna.

Allowing for the tip the pinna is narrow-deltoid, the upper segments being narrower and shorter than the lower. The lower segments are separated almost to the rhachis, the upper, about three fourths the way. Segments rhomboid, blunt pointed, both margins crenulate. The largest segment is 10 mm. long by 4 mm. wide.

Venation: The mid-rib of each segment enters near the lower edge and crosses the segment diagonally as an undulating line to the apex. From it are given off on either side 3 or 4 secondary nerves which fork once or twice, the veinlets running free to the margin, each marginal tooth always having a vein terminating in it.

Sori: The position of the sori, which apparently were small, is on the lateral veins which may be produced beyond them or not. Each lateral vein has a sorus on its inner branch. There are 4 or 5 sori on each side of the mid-rib and about midway between it and the margin.

This fern belongs to the typical section of *Dryopteris*. The Recent New Zealand species are not closely related as all have much narrower and distinctly serrated segments.

Lomaria proceroides Oliver n. sp. (Fig. 24).

Several incomplete pinnae. 20-23 mm. wide.

Nerves free, a few fork at or near their origin; terminating in the ends of the serrations at the margin of the pinna; 1 to 1.2 mm. apart.

Pinna lanceolate, narrowing gradually towards the base, then turning in more abruptly. The serrations are not so marked at the basal end.

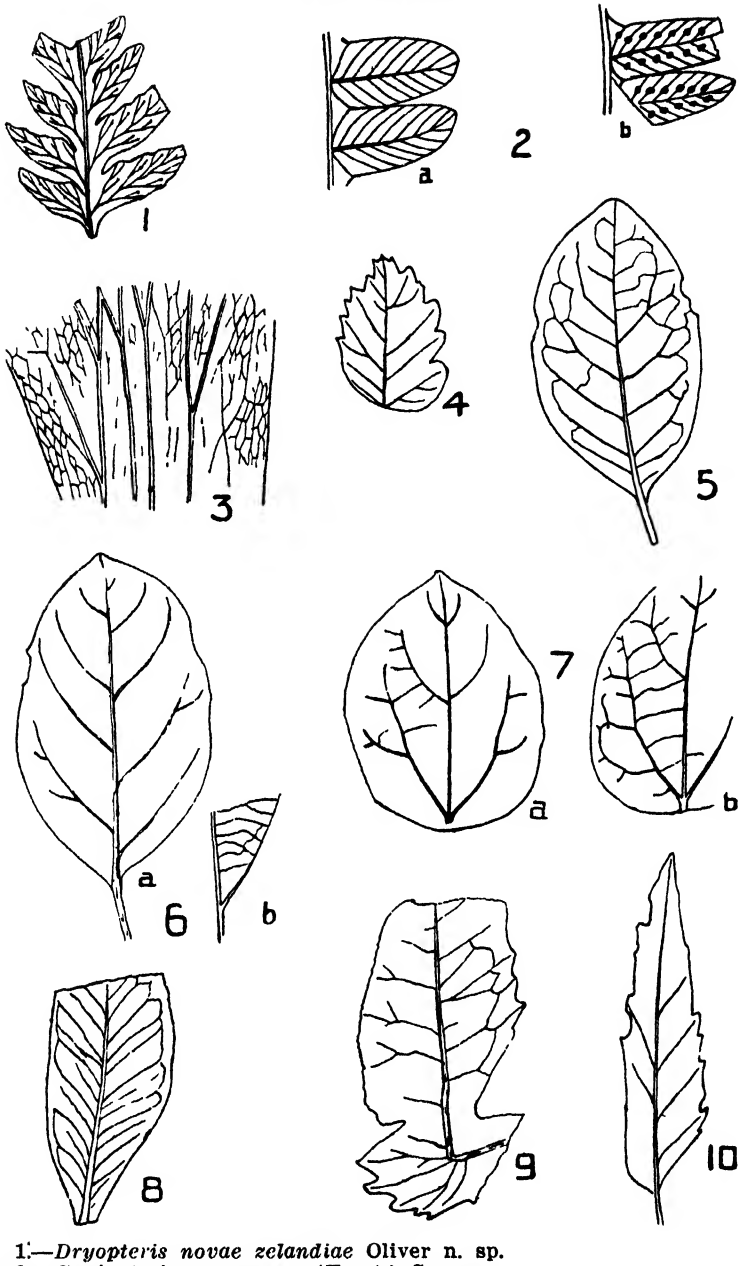


FIG. 1.—*Dryopteris novae zelandiae* Oliver n. sp.
FIG. 2.—*Goniopteris pennigera* (Forst.) Spreng.
FIG. 3.—*Platycerium morgani* Oliver n. sp.
FIG. 4.—*Nothofagus fusca* (Hook. f.) Oerst.
FIG. 5.—*Litsaea calicaris* (A. Cunn.) Benth & Hook. f.
FIG. 6.—*Beilschmiedia ovata* Oliver n. sp.
FIG. 7.—*Clematis obovata* Oliver n. sp. a, upper surface; b, lower surface.
FIG. 8.—*Apocynophyllum novae zelandiae* Oliver n. sp.
FIG. 9.—*Plagianthus antiquus* Oliver n. sp.
FIG. 10.—*Rubus australis* Forst.

This species agrees with *Lomaria procera* (Forst.) Spreng. in everything save the shape of the base of the pinnae. In *L. procera* the base is truncated or even dilated, although in very young pinnae it is somewhat narrowed. Pinnae of the same size as the fossil specimen are, however, never narrowed towards the base.

Pteridium esculentum (Forst.) Ckn. (Fig. 25).

Carbonized impressions of both sides of a portion of a frond.

Pinnule 17 mm. long, lowest segment 4 mm., breadth of segment 1 mm.

The segments are linear, straight or slightly curved, obtuse. Pinnule with about 8 segments on either side. The impression of the under surface shows a central rib and two lateral lines apparently corresponding to the indusia.

The veins are well seen in several places. They are free, and once forked near the base.

Pinnules sessile, alternate, lanceolate, broadest at the base, the lowest segments longest and springing from near the rhachis. There does not appear to be a long terminal segment. Upper basal segment shorter than the lower.

The specimens agree with *Pteridium esculentum* in most of the characters. It differs in the rather narrower segments though *P. esculentum* when dried sometimes has segments 1 mm. wide. No long terminal segment is shown in the fossil, which, however, may be imperfect.

Goniopteris pennigera (Forst.) J. Smith (Fig. 2).

Fragments of pinnae consisting of several more or less imperfect pinnules and a portion of the rhachis.

Segments obtuse or subacute slightly curved towards tip of leaf, margin entire. Rhachis as a double line, indicating the upper surface of the leaf. Segment 12 mm. long.

Nerves free, parallel, 8-12 on each side of midrib, sub-opposite to alternate. The lowest pair united with those on adjacent segments. The veins are close being slightly less than 1 mm. apart.

In another specimen the segments measured 14 mm long.

Another specimen shows sori on the veins, mostly midway between midrib and margin, though some are nearer the midrib, in one instance there is a sorus on the lowest vein.

This specimen matches almost exactly Recent specimens except in the nerves being closer together.

Platycerium morgani Oliver n. sp. (Fig. 3).

The specimen consists of the impression of a fragment of a frond showing distinctly the major and minor veins.

The sides diverge at an angle of 25°. Along a length of 3 cm. the leaf increases from 4 cm. to 5 cm. in width.

The venation consists of anastomosing veins of two orders. The deeper impressions make lacunae 5 to 10 mm. in width and none are complete in the length of frond (5 cm.) represented. Over the whole of the interspaces is a finer network giving elongate more or less hexagonal meshes 1 to 2 mm. wide and 4-6 mm. long.

Another and larger impression shows a precisely similar type of venation. The veins are very clear, and in several a short vein extends and ends freely in a slight dilatation.

I place this species with little doubt in the genus *Platycerium* as the type of venation agrees very closely with *P. alcicorne*. It is dedicated to the late Mr. P. G. Morgan, Director of the New Zealand Geological Survey, who kindly placed the present collection in my hands for description.

Typha angustifolia Linné.

Impression of leaf, both surfaces.

The impression is of a linear leaf 12 mm. wide with longitudinal striation. The fragment is 7½ cm. long. There is no indication of ribs, and it is therefore referred to *Typha*. The striations are fine and of a similar type to those of *T. angustifolia*.

Dried leaves of *Typha angustifolia* show about 12 ribs but if the impression was of an unshrunken leaf the ribs would not show.

Rhopalostylis sapida (Forst.) Wendl. & Drude (Fig. 26).

Impressions of leaves of this palm are quite common in the pumice silts. The best specimen consists of the midrib of a leaf, 25 cm. in length, showing 4 pinnae arising on one side. A leaflet 10 cm. from its origin is 3 cm. in diameter.

The stem is about 1 cm. in width. It shows no definite markings.

The pinna converges towards the base where, opposite its inner junction with the midrib, it is 2 cm. in width.

The pinnae show close parallel veins, with a prominent midrib, or on the upper surface, depression, and usually one prominent rib on each side of the midrib near the margin.

The pinnae are placed at the same distance apart as in the Recent species, but they appear to be joined by a wider base.

Nothofagus fusca (Hook.) Oerst. (Fig. 4).

Leaf impression, upper surface, basal portion incomplete.

Length along midrib 29 mm. Distance midrib to right side 12 mm, to left side of 9 mm.

Leaf ovate narrowing in the distal half to a 3-dentate lobe, coarsely and irregularly serrate.

The secondary nerves are fairly regularly arranged, diverging at an even angle on either side of the midrib, running approximately parallel, and ending in the apexes of the teeth. There are 4 on the right side and 5 on the left. The lower one on the right side has two strong branches on its under side, the upper one is forked near the base, the middle one on the left side is forked about half-way to the margin. Under the microscope the whole lamina appears finely reticulated, the larger nervules crossing between the secondary nerves at right angles to them.

The leaf corresponds in all its characters with that of *Nothofagus fusca*, though the angle at which the secondaries spring is not quite so acute.

Paratrophis cuneata Oliver n. sp. (Fig. 27).

A hardened piece of silt contains portion of a leaf impression.

The complete leaf would be elliptical, tapering gradually from the centre towards base and apex, but evidently broadest nearer the apex.

The margin is coarsely sinuous, not bounded by a conspicuous nerve.

Length of lower portion 85 mm., breadth 40 mm. Estimated length of entire leaf 14 cm.

The midrib is strong and of considerable width, being 2 mm. wide at the base. The secondary nerves are weak and irregularly spaced, and branch frequently, the main portion arching forward to join the nerve above. The whole surface of the leaf is finely and distinctly reticulated into 4 to 6-sided polygons, in many of which the nerve endings appear to terminate freely. The secondaries spring at an angle of about 70° from the midrib.

In its sinuated margin and type of venation the leaf agrees with *Paratrophis*. It is much larger than *P. opaca*, and a point of difference is the method in which the secondaries arise from the midrib. In the fossil species the base of each curves away from the midrib, in *P. opaca* it meets it abruptly. The fossil also narrows more decidedly from the broader distal end towards the base Its closest ally, however, seems undoubtedly to be *P. opaca*.

Litsaea calicaris (A. Cunn.) Benth. & Hook. f. (Fig. 5).

Impression of both sides of leaf.

Leaf regularly elliptical, tapering rather abruptly at both ends, the sides unequal and the base also slightly unequal, quite entire. Apex blunt. The leaf was apparently smooth and thin.

The midrib and secondary nerves are well marked, all the others are easily seen with a hand glass. Of the secondaries about 6 are well marked on either side diverging at an angle of about 60°, nearly opposite. Tertiary nerves with coarse reticulation, the lacunae entirely filled in with minute 3-5 sided cells. The secondary nerves arch round and join the ones in advance well in from the margin.

Length of petrole 9 mm., lamina 60, breadth left of midrib 17, right of midrib 15 mm.

The leaf appears to agree in every particular with that of *Litsaea calicaris*.

Beilschmiedia ovata Oliver n. sp. (Fig. 6).

Several impressions of leaves giving details down to the minute surface reticulation.

Lamina, regularly elliptical, obtusely pointed at apex and base. Some specimens show the apex truncated and split so as to appear retuse. Margin entire.

Lamina 74 × 37 mm., 61 × 37 (truncated apex).

Midrib wide and well impressed, striated. Secondaries: 4 or 5 prominent ones on either side, arising at an angle of about 40° from the midrib and curving slightly towards the apex. They approach but do not quite reach the margin, curving round almost parallel to it. A few weak tertiaries are present springing from the

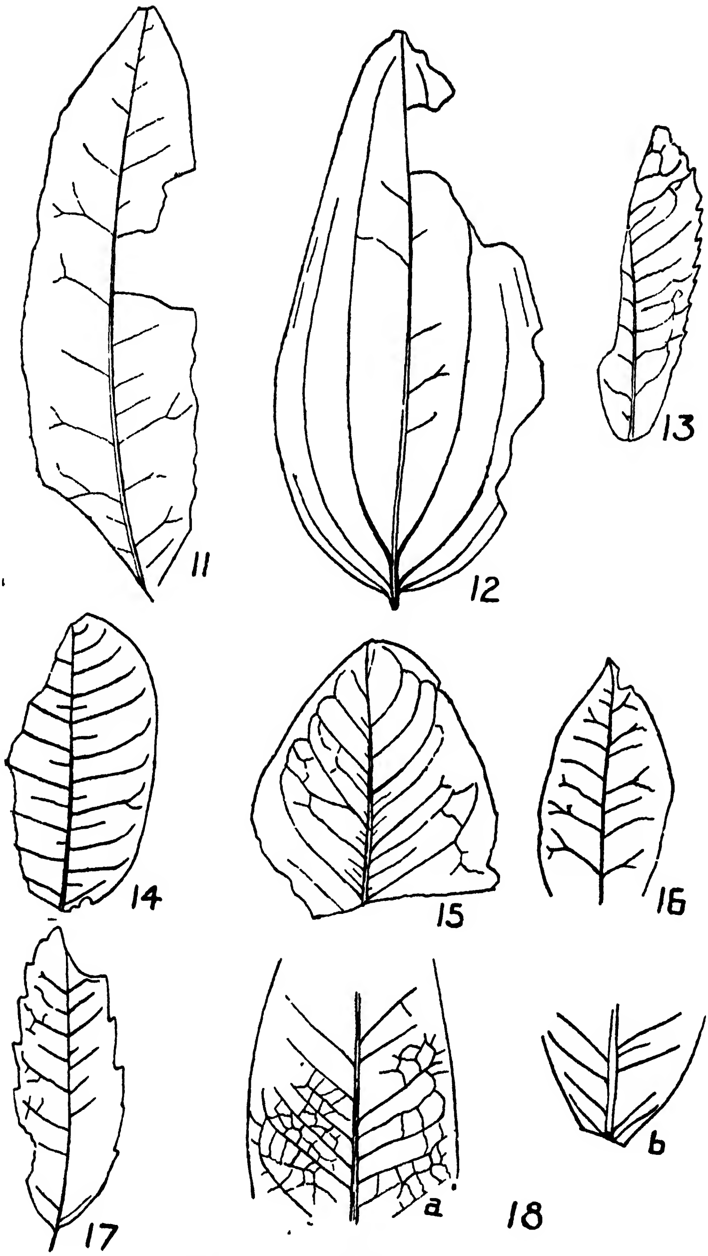


Fig. 11.—*Knightia fossilis* Oliver n. sp.
Fig. 12.—*Coriaria arborea* Lindsay.
Fig. 13.—*Ceratopetalum pacificum* Oliver n. sp.
Fig. 14.—*Pittosporum oblongum* Oliver n. sp.
Fig. 15.—*Apocynophyllum inaequilaterale* Oliver n. sp.
Fig. 16.—*Melicope elliptica* Oliver n. sp.
Fig. 17.—*Quintinia waipaoaensis* Oliver n. sp.
Fig. 18.—*Nothopanax reticulatum* Oliver n. sp.

distal outer sides of the secondaries. Weaker veins cross fairly regularly between the larger veins, and there is a fine reticulation over the whole surface.

In their shape and type of venation these leaves correspond very closely with the Recent *Beilschmiedia tarairi.* The chief differences are: the lower secondaries springing at an acute angle instead of nearly a right angle as in *B. tarairi*; obtuse apex not showing the mucro of the young leaf of *B. tarairi*; less prominent and fewer principal nerves.

Knightia fossilis Oliver n. sp. (Fig. 11).

(a) Impression of a leaf, base imperfect. Leaf oblong-elliptical, slightly curved, distally tapering rather suddenly to the apex which is not quite complete; margin wavy and irregularly serrate. Length 115 mm., breadth 30 mm.

(b) Portion of leaf, both base and apex missing, margin wavy and irregularly serrate, the serrations much more pronounced than in specimen (a). Breadth 30 mm.

These two specimens are associated together on account of the type of surface and venation which correspond exactly. They only differ in the margin.

The midrib is well marked; all the other veins are weak. The secondaries spring at an angle of 45-50° from the midrib and at irregular distances. They fork into two main branches rather nearer the margin than the midrib. The whole surface is finely and clearly reticulated, the nerves terminating freely in the meshes.

The type of venation corresponds precisely with that of *Knightia excelsa* R. Br., and hence the specimens are referred to *Knightia.* The difference from *K. excelsa* lies in the character of the margin which is irregular in the fossils, but fairly regularly dentate in the Recent species.

Coriaria arborea Lindsay (Fig. 12).

Impression of large leaf.

Leaf obovoid, broadest about ¼ from base, sides beyond the broadest part rather straight, gradually tapering and then turning in towards apex which is produced into a blunt point. Margin entire. Rounded at the base.

Lamina 105 × 50 mm.

Seven longitudinal ribs present.

Midrib strong. On either side is a strong rib, confluent with the midrib at the base for about 1 cm., then arching out and again converging at the apex. On either side of these are two longitudinal ribs, considerably weaker. The inner ones can be traced nearly to the apex, but the marginal ones can only be followed 3 or 4 cm. The secondaries arise from the longitudinal nerves, and join up to the longitudinal nerve or margin outside them. The leaf is faintly reticulated with rather large meshes.

The leaf agrees entirely with the Recent *C. arborea* though it is very large for that species. There are also present in the collection two imperfect impressions of smaller leaves.

Clematis obovata Oliver n. sp. (Fig. 7).

Leaf impression of both surfaces, complete except for portion of one side and the petiole.

Lamina—length 50 mm., breadth 38 mm. The midrib not in the centre, the distances to the margins being 20 and 18 mm.

The shape is broadly ovate, truncate at the base, broad for more than half the length, then tapering to the apex, which is not quite complete, but appears to have been produced into a short point.

The nerves are few, prominent, and wide. Two strong secondaries arise from near the base of the midrib, diverge at an angle of about 40°, and extend to nearly three-fourths the distance to the apex. At more than half-way up two other strong ribs, nearly opposite, diverge at a wider angle and arch round towards the margin about three-fourths the way to the apex. Near the apex is a third pair of strong nerves nearly opposite. The secondaries branch with the strongest branches on the outside, but branches also cross from secondary to secondary, and from secondary to midrib at an angle of 90 to 100° from the midrib. There are indications of a fine reticulation over the whole surface. The outer branches of the secondaries arch round towards the apex.

This leaf does not resemble closely any plant at present living in New Zealand. In its shape it recalls *Clematis indivisa* Willd., but the venation is different. The venation is, however, not unlike that of *C. hexapetala* (Forst.). Hence rather than refer it to any genus not found in New Zealand, I am describing it as an extinct species of *Clematis.*

Two impressions of achenes of *Clematis* are in the collection and may be described here, although, of course, they are not attached to any leaves, and therefore the proof that they belong to the same species as the leaf above described is lacking.

In one the achene is 6 mm. in length, with a style 40 mm. long. The achene is elliptical, more convex on one side than the other, and is shortly stalked or at least produced at the base.

It differs from the achene of *C. indivisa* in being slightly larger and in possessing a short stalk.

Apocynophyllum novae zelandiae Oliver n. sp. (Fig. 8).

Two well preserved impressions of leaves, in both cases with the upper portion of the leaf wanting.

Lamina lanceolate, narrowing gradually to the base, unequal sided, in the middle portion the sides nearly parallel. Margin entire.

Midrib broad and shallow at the base narrowing above. Secondaries all fine, numerous, and with many short fine nerves arising from the midrib between them. The principal secondaries take a slightly sinuous course to near the margin, then turn parallel to it to join up with the next distal secondary. Ultimate reticulation of small meshes faintly marked.

Width of lamina 23 mm.; estimated length about 90 mm.

I am unable to refer this species to any Recent genus of New Zealand plants. In the type of venation, namely, the numerous secondaries, connecting near the margin, it seems to approach the Tertiary *Apocynophyllum,* and hence is provisionally referred to that genus. Of the published figures to which I have had access, it resembles most *A. Mackinlayi* of Vegetable Creek, New South Wales.

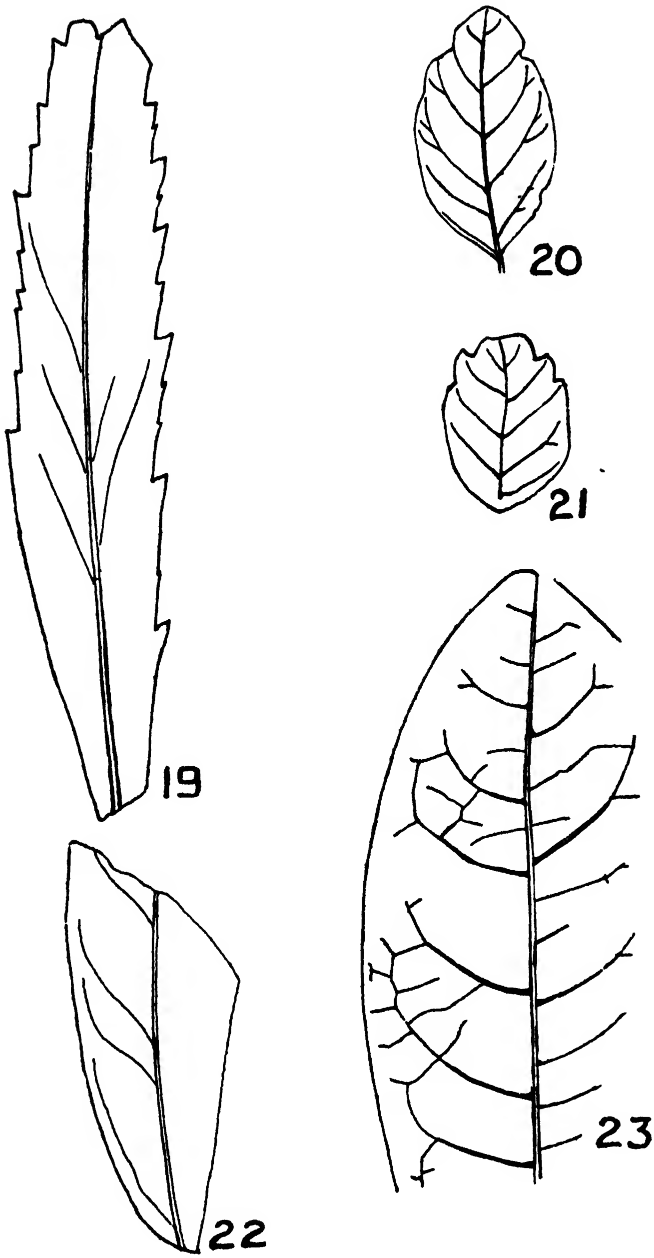


FIG. 19.—*Pseudopanax crassifolium* (A. Cunn) C. Koch.
FIG. 20.—*Parsonsia obtusa* Oliver n. sp.
FIG. 21.—*Pennantia corymbosa* Forst.
FIG. 22.—*Hebe salicifolia* (Forst.) Pennell.
FIG. 23.—*Coprosma vulcanica* Oliver n. sp.

Apocynophyllum inaequilaterale Oliver n. sp. (Fig. 15).

Distal portion of impression of a leaf.

Lamina broad, narrowing gradually to a broad blunt apex. Apex conspicuously unequal sided, the angle of midrib and margin being acute on one side, but about a right angle on the other.

Measurements of the fragment 50 mm. long, 42 mm. broad. The entire leaf is estimated to be 100 mm. long, and 50 mm. broad.

All the veins are faintly marked, indicating that they were not prominent in the living leaf. The midrib is broad. The secondaries are all narrow, and many fine ones are interspersed among the more prominent ones. These latter arch round on nearing the margin to join up with those in advance. The ultimate reticulation consists of small meshes faintly marked.

The present leaf impression resembles *Griselinia* in its general outline and unequal-sidedness. The type of venation is, however, altogether different and more nearly approaches that of *Apocynophyllum.*

Plagianthus antiquus Oliver n. sp. (Fig. 9).

Imperfect impression of a leaf. The leaf appears to have been broken, for the midrib is bent at about 100° near the base.

Lamina roughly oblong, coarsely and irregularly serrate, the serrations at the base becoming progressively smaller towards the petiole. The teeth are rather bluntly pointed.

Length 60 mm., but apex missing. The leaf is estimated to have been about 80 mm. in length.

Midrib broad and shallowly impressed. Secondary veins weak, arising from the stem at an angle of about 60°, irregularly spaced, and quite irregular in their branching. Some branch near the midrib, others distant from it, while they take irregular courses. Each terminates in a tooth at the margin, and the principal branches may also end in teeth. A fine reticulation covers the whole surface of the leaf.

In the general shape of the leaf, and the type of venation, the fossil agrees with *Plagianthus reqius* (Poit.), but it differs in being more oblong, and in the secondary veins being less regular in their courses and in arising from the midrib at a much wider angle.

Leptospermum pliocenicum Oliver n. sp.

Branching specimen containing several capsules.

The branches are slender, with a few longitudinal ribs.

No leaves are preserved.

The capsules are small, a little broader than high with convex sides and convex crown. At the outer angle are slightly projecting points evidently representing the calyx segments. There is, in most cases, a short persistent style.

The pedicel is slightly longer than the height of the capsule. The capsules arise singly at short intervals on the twigs.

Length of capsule 2 mm., of pedicel 2.5 mm.

The capsules agree in size, shape and length of pedicels with young fruit of the Recent *L. ericoides* A. Rich. The ridging of the young stems is also similar in the two forms. The arrangement of

the capsules in the stem is, however, different. In *L. ericoides* they occur in groups either on the main branchlets or on short lateral branchlets; in the fossil they occur singly.

Carmichaelia australis R. Br. (Fig. 28).

Two large impressions of branches.

The largest specimen is 25 cm. long, and consists of a branch bearing several short branchlets, each ramifying in the way characteristic of the genus. The impressions are bad, but here and there the striations of the branches are evident. The branches are 3-5 mm. in width.

So far as the details are preserved, that is, in habit, size and striation, the specimens resemble the Recent *C. australis*, and so may provisionally be referred to that species.

Rubus australis Forst. (Fig. 10).

Impression of leaf, complete.

Lamina lanceolate, broadest near the base, thence gradually tapering to the apex, inequilateral, and unequal sided at the base, the wide side diverging at a narrower angle and higher up than the narrow side. Coarsely and fairly regularly serrate.

Length of lamina 65 mm., width 44 mm., 5 mm. from midrib to one margin, and 9 mm. to the other.

Midrib well defined. Secondaries wide apart, branch off at an angle of about 40° and terminate in the teeth. The whole surface finely reticulated.

Two other smaller specimens agree essentially with the above described leaf.

In its general characters these leaves agree with the Recent *Rubus australis*. In the secondary nerves leading direct to the serrations, however, it approaches *R. schmidelioides* A. Cunn., so that perhaps in the Pliocene as now hybridization was going on in the New Zealand species of *Rubus*.

Pittosporum oblongum Oliver n. sp. (Fig. 14).

Impression of both surfaces of leaf, that of upper not good, that of under surface one side nearly perfect, the other (left) partly missing. Apex missing.

Leaf broadly elliptical rounded off rather abruptly at apex and base. Margin entire.

Length of lamina 57, width from midrib to right side 16 mm.

Midrib and secondaries prominent, remainder obscure. The secondaries arise at an angle of 70° to 75°, arch little or not at all for most of their course, and turn rather abruptly near the ends towards the apex of the leaf. There are 11 principal secondaries on the right side, and between these here and there are shorter ones. Secondaries alternate or opposite. Tertiaries weak, but show fairly large reticulations.

The leaf has the characters of a *Pittosporum* and agrees with *P. colensoi* Hook. f., except that the basal angle is broader and the secondary veins spring from the midrib at a wider angle.

Ceratopetalum pacificum Oliver n. sp. (Fig. 13).

Impression of the greater portion of one side of a leaf and the base.

Lamina narrowly obovate, base rounded. Margin irregularly serrate, generally a larger tooth alternating with a smaller one.

Length estimated at 4.5 cm., breadth 1.8 cm.

Midrib broad and well marked. Secondaries numerous but weak, breaking up before reaching the margin, and their branches terminating in the serrations. The ultimate reticulation shows large meshes.

I cannot refer this species to any New Zealand genus. It is, however, not unlike the Recent and Tertiary *Ceratopetalum* of Australia, and may be provisionally placed in that genus.

Melicope elliptica Oliver n. sp. (Fig. 16).

A well-preserved impression of a leaf with the base imperfect.

Lamina broadly elliptic, unequal-sided, the broadest part of one side being just in advance of the centre of the leaf, while that on the other side is behind the centre. Apex rather acutely pointed. Margin slightly irregular but entire.

Width of leaf 23 mm.; estimated length 50 mm.

Midrib well marked by a dark shallow depression. Margin marked by a continuous dark line. Eight to ten secondaries on each side arising from the midrib at an angle of about 55°. They usually break up by dividing into two a little nearer the margin than the midrib. The ultimate reticulation is faintly marked with small meshes.

Within each mesh there is seen under a strong lens, a dark spot. These spots do not seem to be connected with a nerve ending, and hence probably represent oil glands.

The leaf agrees with the Recent *Melicope ternata* Forst. in the type of venation, marginal line and presence of oil glands. It only differs in the shape of the lamina, being more acutely pointed than in the Recent species which is broadest near the distal end giving an abruptly pointed apex, while it narrows gradually to the base.

Quintinia waipaoaensis Oliver n. sp. (Fig. 17).

Leaf impression imperfect at the tip.

Lamina oblong, obtuse at apex, tapering rather abruptly at base. Margin with large regularly spaced serrations.

Petiole short.

Length of lamina 57 mm., breadth 20 mm., petiole 5 mm.

Midrib well marked as also are 10-12 secondary nerves on either side. These diverge at an angle of about 65°, are straight for three-fourths of their way to the margin, when each breaks up sending a branch above and below to serrations. The basal portion of the secondary nerve usually points to a position between two of the marginal teeth. The leaf surface is faintly reticulated with small meshes.

The leaf is referred to *Quintinia* because its type of venation agrees with the members of that genus. It differs from the Recent species in the shape and outline of the lamina.

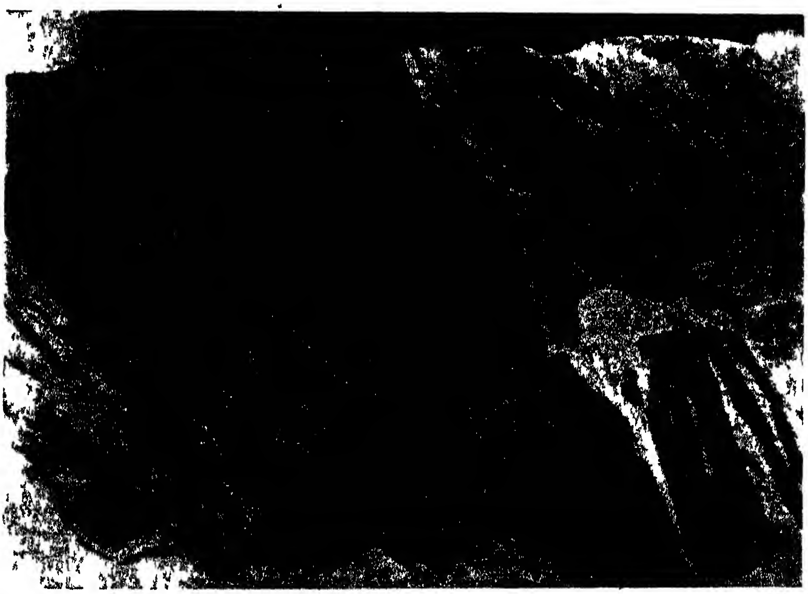



Fig. 24.—*Lomaria proceroides* Oliver n. sp.
Fig. 25.—*Pteridium esculentum* (Forst.) Ckn.
Fig. 26.—*Rhopalostylus sapida* (Forst.) Wendl. and Drude

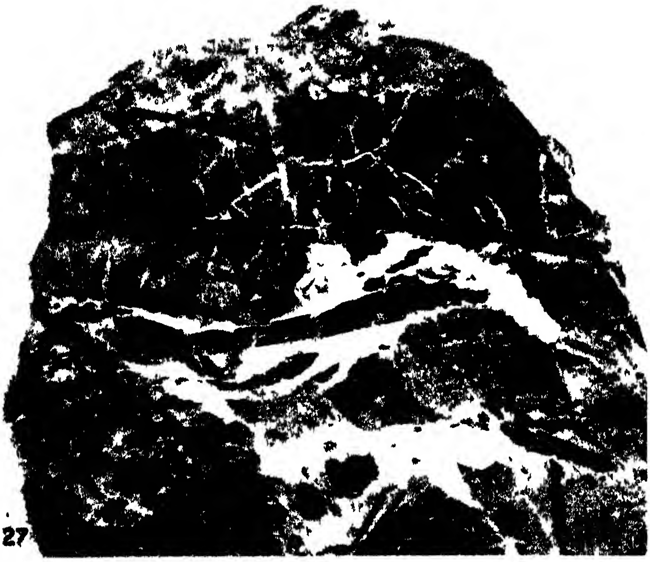


Fig. 27.—*Paratrophis cuneata* Oliver n. sp.
Fig. 28.—*Carmichaelia australis* R. Br.

Melicytus ramiflorus Forst.

Impression of portion of leaf.

Lamina ellipitical, tapering in the distal half, regularly dentate, the serrations having a longer curved lower side and a shorter upper side.

Width from midrib to margin 2 cm.

The estimated size of the lamina is 10 × 4 cm.

Midrib strong. Secondaries strong, arising from the midrib at various angles 50° to 65°: each curves distally as a prominent vein and, running nearly parallel to the margin, joins up with the vein in front. From this marginal festoon, nerves run towards the margin curving forwards to the teeth. A fine meshed reticulation is evident in places.

In shape, margin and venation the impression agrees with the Recent *Melicytus ramiflorus.*

Nothopanax reticulatum Oliver n. sp. (Fig. 18).

Impressions of two leaves both imperfect as regards apex and base.

Lamina broadly lanceolate, gradually narrowing towards the tip, but more abruptly towards the base; margin entire.

Width 40 mm., length estimated to be 12-14 cm.

The midrib is broad and well impressed. The secondaries are numerous and arise at fairly regular intervals and at an angle averaging 50° from the midrib. Near the base the angle is wider, except in the case of the lowest two or three veins on either side. On nearing the margin the secondaries arch round and join those in front. The ultimate reticulation is well marked with fairly large polygonal meshes.

The present leaves resemble those of the Recent *Nothopanax Edgerleyi,* but differ in the following points: the base is more abruptly narrowed, the reticulation is finer and does not show the regular loops of the Recent species.

Pseudopanax crassifolium (A. Cunn.) C. Koch. (Fig. 19).

Impression of upper surface of leaf, imperfect at each end.

Leaf lanceolate, gradually tapering towards the base. The margin coarsely and sharply serrated. The lower teeth 20-22 mm. distant, the upper 8-12 mm. Between the larger teeth are, in most cases, one to three much smaller ones; absent in the lowest portion, 3 in the longer intervals and 1 in the upper portion of the leaf. The teeth are sharp pointed.

Total length of preserved portion of leaf 120 mm., width 23 mm. The complete leaf would be not less than 150 mm. in length.

The midrib is well marked, just over 1 mm. in diameter at the base and tapering towards the tip. Secondary nerves very faintly marked. They spring from the midribs at an angle of 25° to 30°. The ends are directed towards the notches but just short of them they fork, the lower branch going towards the apex of the tooth, the upper continuing parallel with and near the leaf margin.

The leaf agrees in all its characters with *Pseudopanax crassifolium.*

Parsonsia obtusa Oliver n. sp. (Fig. 20).

Several leaf impresions, some with the carbonized remains of the leaf still attached.

Lamina broadly or narrowly eliptic, blunt pointed, base broadly cuneate. Margin entire.

Lamina 37 × 21 mm.; 30 × 14 mm.

The midrib and secondary veins are deeply impressed, and therefore must have been prominent in the leaf. There are a few prominent branches, otherwise the veinlets are weak. There are five secondaries on either side of the midrib, branching at an angle of 40°-45° and curving forward near the margin, but not quite reaching it. Tertiaries given off mainly from the outer side of the secondaries similarly approach the margin. A fine reticulation covers the entire space between the prominent veins.

The position of these leaves is doubtful. They are referred to *Parsonsia* because of the characters of the secondary and tertiary veins, but they differ in shape, non-mucronate apex, and in the presence of a fine surface reticulation.

Pennantia corymbosa Forst. (Fig. 21).

Impression of both surfaces of a leaf.

Leaf oblong, base rounded, apex truncate, sides nearly parallel, with six rounded blunt teeth on the distal half, of which one appears to be mucronate.

Length 26 mm., breadth 18 mm.

The midrib and secondary ribs are well marked but not deep. There are four principal secondary ribs on either side of the midrib arising at an angle of 50°, nearly opposite, the upper two on each side terminating in the apexes of the teeth. The remaining nerves are obscure, but there are indications of a large meshed reticulation.

The leaf agrees very well with intermediate leaves of *Pennantia corymbosa,* except that the base is more rounded than is usual in the Recent form.

Hebe salicifolia (Forst.) Pennell (Fig. 22).

Impression of both surfaces of a portion of a leaf.

Leaf broadly lanceolate, entire.

The length of the impression is 7 cm. It represents about half a leaf. Distance from midrib to margin 13 mm.

The midrib is well marked, fairly broad and not high. The secondary ribs are very faintly marked. One near the base branches at a small angle and runs parallel to the margin. Others further up branch at wider angles, arching round until they are nearly parallel to the margin.

The leaf impression agrees in all points with the Recent species, *Hebe salicifolia,* and may accordingly be entered as such.

Coprosma vulcanica Oliver n. sp. (Fig. 23).

Portion of a leaf, about ¾, with impression of both upper and lower surfaces.

The part preserved measures 93 × 43 mm. In the broadest portion the distance from margin to midrib is 26 mm. The complete lamina is estimated to be 130 × 52 mm.

The margin is entire. Only one side of the apex is preserved. It is obtuse and bends in towards the termination of the midrib. If this is not due to an injury or loss in preservation it indicates an emarginate apex.

The general form of the leaf is elliptic, the broadest portion being distal to the centre.

Midrib strong, prominent. Secondaries: 4 or 5 strong ones on each side, with smaller ones between. They arise from the midrib at a wide angle, curve regularly, though somewhat fastigiately, and are united near the margin by a branch of the secondary distal to each. The tertiaries are fine and indicate a fairly large meshed reticulation. The discoloured margin indicates a marginal vein. Domatia are indicated at the bases of most of the secondary veins.

The leaf agrees essentially with the large leaved Recent species of *Coprosma*. It perhaps comes closest to *C. australis* (A. Rich.) (= *C. grandifolia* Hook. f.) especially in the venation. It differs in the following points: the angle of the secondaries and midrib is wider, the shape is different being less cuneate at base and apex, the apex is apparently emarginate.

The Epiphyllous Lichens of Kitchener Park, Feilding, New Zealand.

By A. Zahlbruckner, K. Keissler and H. H. Allan.

[*Read before the Philosophical Institute of Canterbury, 8th June, 1927; received by Editor, 20th April, 1928; issued separately, 10th August, 1928.*]

A. ECOLOGICAL (H. H. Allan.)

1. Introductory.

Hochstetter, in his classical sketch of New Zealand vegetation (1863, p. 417), was the first to emphasize the tropical or subtropical character of New Zealand forests. Made familiar by citation in Schimper's *Pflanzen-Geographie*, this view has gained wide currency, and subsequent research has only served to confirm it. The most recent treatment is that of Cockayne (1926, p. 7), who divides the New Zealand forests into the two great classes "subtropical rain-forest" and subantarctic rain-forest." In enumerating the special characteristics of these rain-forests he concludes with, "(13) small bryophytes and lichens frequently occur as epiphytes on leaves of trees." This last feature has not hitherto received the attention its interest and importance merit. The only work so far done appears to be the well-known paper of Jennings (1896, p. 753), in which are described two species of *Phycopeltis*—*P. nigra* and *P. expansa*—and the association of the latter with a fungus to produce the lichen *Strigula complanata* is shown.

My own observations would lead me to suggest a modification of Cockayne's statement. I find epiphyllous bryophytes and algae occasional on the leaves of the shrub-layer, but rare on forest-trees. On shrubs in very humid forest the epiphyllous bryophytes may become frequent. I find epiphyllous lichens to be comparatively rare, but to occur on leaves of plants of all layers. These findings agree with those of Dr. G. E. Du Rietz, who recently made a lichenological survey of New Zealand.

The small remnant of forest, however, near Feilding, known as Kitchener Park and fortunately constituted a "reserve," has epiphyllous lichens in abundance (algae and bryophytes are not wanting as epiphylls, but are of much less moment), and provides a convenient area for their study. Opportunity was therefore taken to secure the services of the doyen of lichenology,, Hofrat Dr. A. Zahlbruckner, Director of the Department of Botany in the Natural History Museum of Vienna. The results of his work are given in section B, and provide a sure basis upon which ecological work can be built. In section C his colleague, Professor Dr. Karl Keissler, describes and discusses a new lichen-parasite of considerable interest that was discovered on certain specimens.

An attempt is made in this section to give a preliminary account of the ecological problems presented by the phenomena observed at

Kitchener Park. It will be realized, however, that at the present stage of our knowledge, only very general and introductory work can be expected. Nothing, *e.g.*, of moment is known concerning the life-history of the leaves of any of our "evergreen" trees. This preliminary account, however, may have its value in drawing attention to a group of problems that apart from their intrinsic interest, must have an important bearing on general forest ecology.

2. THE PROBLEMS ENVISAGED.

Ward (1884, p. 115) observed, "The whole group of 'Epiphyllous Lichens' would no doubt well repay prolonged and careful investigations." The work so far accomplished on the ecology of epiphyllae has brought to light many of the problems concerned, but has not made much advance towards solving them. Ward's own contribution is (*loc. cit.*, p. 87), " The organism to be described [*Strigula complanata*] occurs on the upper surface of the leaves of so many plants widely separated in affinity and origin, that one must regard the species of the supporting plant as an accident. One general feature, however, is common to all these leaves: they are invariably hard and persistent, differing moreover, in degree in this respect." Schimper (1903, p. 328) merely remarks that epiphyllous forms of cryptogams are " apparently confined to the tropics," and are " quite common features, particularly on ageing leaves, in very humid rain-forests." The ground-breaking paper of Fitting (1910, p. 505) still remains the most important and suggestive work yet published. It is the only paper cited by Warming and Graebner (1918, p. 288) and Fünfstück (1926, p. 11) in their brief treatments of the subject. Curiously it is not cited in the ecological chapter of Smith (1921, p. 356 *et seq*.). That author remarks (*loc. cit.*, p. 363) concerning epiphyllous lichens, "These grow on Ferns or on the coriaceous leaves of evergreens in the tropics. . . . . Observations are lacking as to the associations or societies of these lichens whether they grow singly or in companies."

Fitting (*loc. cit.*, p. 506) classes the crustaceous lichens of the upper surface of leaves in the Javanese forests studied by him, into three groups: (1) a small group the members of which penetrate more or less deeply into the leaf-tissues causing local injury or death of the parts; (2) a large group the members of which cause the cuticle to peel off, and establish themselves on the outer walls of the epidermis; (3) a small group the members of which grow on the cuticle without injury to it. In this group may be included certain foliaceous lichens "in Gegenden mit sehr feuchter Atmosphaere."

The influence on the leaf-tissues he considers comparatively small, the leaf reacting by way of the thickening of the outer walls of the epidermis or even of the outermost layer of palisade cells, and by the development of wound-cork. The damage done must be attributed to the alga as well as the fungus, and he concludes that the first, and to a less extent the second, group must be considered as parasitic, not merely epiphytic. He cites Busse's opinion, with modified approval, that epiphyllous lichens are confined to evergreen leaves, mainly those that are smooth and leathery. Very hairy leaves are free, but drip-tips and other adaptations favouring quick removal

of water from the leaf-surface have no effect in checking lichen growth on the surface. He thinks it not a general rule, as Busse considers, that leaves unprotected from heavy downpours and exposed to sun are only lichenized if a damp atmosphere persists during the dry period. Busse's statement that shading favours settlement is considered to be true only of group 3, the others requiring a certain intensity of light.

Fitting concludes by mentioning certain unsolved problems. It is very doubtful whether the qualitative and quantitative differences in the lichen-flora on leaves of different plants is solely to be attributed to different degrees of air-humidity, light-intensity, protection against the impact of rain-drops, wettability of leaves and so on. On what rests the different distribution of lichens on the different leaves of a plant? What determines the often very different lichen-floras of different species? Why do leaf-lichens avoid certain species?

Shreve (1914, p. 86) says "Jungner considers the ready drainage of water from the surface of leaves as of the greatest importance in cleansing them of the spores of epiphyllous hepatics, mosses, etc., and in preventing the presence on the surface of the leaf of a film of water which would be favourable to the growth of epiphyllae. In the Kamerun he has found the leaves with dripping points to be free of epiphyllae unless injured, and the leaves with blunt apices to be full of epiphyllae soon after reaching mature size." After dealing (p. 87) with the epiphyllae of Jamaican rain-forest, Shreve concludes: "Wherever the humidity is high and constant, fog prevalent, and condensation of moisture common, those plants which are sheltered from breeze or subjected to drip from higher layers of foliage bear epiphyllae regardless of whether or not they possess dripping points. Plants of open situations, on the other hand, are devoid of epiphyllae regardless of their form." It is to be noted that the epiphyllae in question were mainly Hepaticae of the genus *Lejeunea*. Shreve (p. 91) mentions that Stahl also rejects Jungner's view.

I am studying the questions raised by these citations, and certain preliminary observations are here offered.

3. Composition and Structure of the Kitchener Park Forest.

A brief account of the remnants, of which Kitchener Park is one, of the great rain-forest that once covered the drainage-area of the Manawatu River has already been published (Allan, 1923, p. 402). It will be sufficient here to indicate the main features of the Kitchener Park forest, in its present much-modified condition.

The dominant species are the tall trees *Podocarpus spicatus* and *P. dacrydioides*. In addition there is in the upper layer much *P. totara* and *Beilschmiedia tawa,* the latter apparently in process of replacing the podocarps. Second-layer trees form a general roof-cover through which project the dominants, these latter having been to some extent felled, thus allowing of a more rapid development of *Beilschmiedia tawa.* The chief trees of this layer are *Alectryon excelsum* and *Beilschmiedia tawa,* with some *Elaeocarpus dentatus, Olea Cunninghamii,* and *Plagianthus betulinus*. Along shallow mud-floored water-channels, often dry for considerable periods, *Cordyline australis* in very large specimens is a true forest member.

There is an irregular third layer, consisting largely of *Hoheria angustifolia, H. sexstylosa* (these two mainly marginal, and there hybridizing), *Melicytus ramiflorus, Myrtus bullata, Nothopanax arboreum, Paratrophis microphylla, Pennantia corymbosa, Pittosporum eugenioides, P. tenuifolium, Pseudopanax crassifolium* var. *unifoliolatum,* and *Suttonia australis.*

The chief members of the shrub-layer are *Coprosma areolata, C. rotundifolia* (and their hybrids), *Melicope simplex, Melicytus micranthus, Myrtus obcordata* (and *M. bullata* $\times$ *obcordata* in numerous forms), and *Nothopanax anomalum.* There are now very few tree-ferns, but *Cyathea dealbata, Dicksonia fibrosa,* and *D. squarrosa* were once common.

The floor-plants of moment are: *Asplenium bulbiferum, Athyrium umbrosum, Carex dissita, Dryopteris decomposita, D. pennigera, Microlaena avenacea, Pellaea rotundifolia, Polystichum Richardi,* and *Uncinia uncinata.*

The more common epiphytes are: *Astelia solandri, Asplenium adiantoides* (under the *Astelia* tussocks), *Bulbophyllum tuberculatum, Cyclophorus serpens, Dendrobium Cunninghamii, Earina mucronata, Pittosporum cornifolium.*

Lianes are numerous, including *Clematis foetida, C. hexasepala* (and hybrids), *Fuchsia perscandens, Metrosideros Colensoi, Parsonia capsularis, P. hetrophylla* (and hybrids), and *Rhipogonum scandens.* On the forest-margins *Muehlenbeckia australis, M. complexa,* along with hybrid forms, are common.

The forest thus shows a general subtropical aspect, though the modifications due to partial milling, entry of stock, and other interference by man, have greatly lessened the density and changed the relative abundance of many species, especially in the undergrowth. The total florula is made up of 38 pteridophytes, 3 gymnosperms, 20 monocotyledons, and 79 dicotyledons. There are 16 groups of hybrids. The growth-forms comprise 29 trees, many also occurring as shrubs, 45 shrubs, 5 semi-woody plants, and 61 herbs. There are 11 epiphytes, 4 hemi-parasites, and 17 lianes.

4. THE DISTRIBUTION OF EPIPHYLLOUS LICHENS IN KITCHENER PARK.

Epiphyllous lichens have been observed on the following species: *Hymenophyllum demissum, H. scabrum, Dicksonia fibrosa, Cyathea dealbata, Polystichum vestitum, P. Richardi, Dryopteris decomposita, D. pennigera, Asplenium adiantoides, A. lucidum, A. bulbiferum, A. flaccidum, Blechnum procerum, Pellaea rotundifolia, Histiopteris incisa, Pteridium esculentum, Polypodium pustulatum, P. diversifolium, Cyclophorus serpens, Podocarpus totara, P. spicatus, P. dacrydioides, Astelia nervosa* var. *sylvestris, A. Solandri, Earina mucronata, Dendrobium Cunninghamii, Loranthus micranthus, Beilschmeidia tawa, Melicope simplex* (uncommon), *Alectryon excelsum, Melicytus micranthus, Metrosideros Colensoi, M. perforata, M. hypericifolia, Myrtus bullata, Nothopanax anomalum, Pseudopanax crassifolium,* var. *unifoliolatum, Olea Cunninghamii.* A number of species, *e.g., Rhipogonsum scandens, Myrtus obcordata,* and various ferns, have been observed with *Phycopeltis tropica,* but with-

out lichens. Thus, of the 140 species found in the forest 38 are found to bear lichens. The following species usually bear them in abundance: *Podocarpus totara, P. spicatus, P. dacrydioides, Earina mucronata, Beilschmiedia tawa, Alectryon excelsum, Metrosideros Colensoi, Myrtus bullata,* and to these especial attention was directed, though many of the others were often well covered. *Theloschistes flavicans* occasionally occurs on the leaves of *Alectryon excelsum, Podocarpus spicatus* and other species, but is not a typical epiphyllous lichen, and is not here further dealt with.

The following data concerning the species attacked are of interest—

(1) *Habitat*:—14 plants of the forest-floor are attacked, 21 of the shrub-layer, 15 of the tree-layer.

(2) *Growth-form*:—There are 17 ferns (5 small, 6 medium, 6 large); 2 tree-ferns; 14 shrubs; 2 semi-woody plants; 3 lianes; 7 trees (which may also be attacked in the shrub-stage).

(3) *Leaf-size*:—22 bear small leaves or leaflets, 11 medium, 5 moderately large.

(4) *Leaf-texture*:—2 are very thin, 13 thin, 18 rather thick, 5 thick.

(5) *Upper leaf-surface*:—26 are smooth, of which 5 are more or less glossy; 12 are very slightly rough. All are glabrous, or practically so, when mature.

(6) *Leaf-apex*:—None possess distinct "drip-tips." In plants not affected only 1 can be said to possess a true "drip-tip."

(7) *Frequency of attack*:—5 are rather rarely attacked, 14 occasionally, 9 frequently, 10 commonly. The most common species of lichen is *Lopadium subcaerulescens*, attacking 31 species. *L. Allanii* may be more abundant than is at present known. Not only are many species attacked, but many leaves may be almost completely covered by the lichen, especially in *Beilschmiedia tawa* and *Alectryon excelsum*. *Strigula africana* appears to be confined to *B. tawa* and *A. excelsum*, but on both may be very plentiful. *Bacidia* spp. appear to be confined to the podocarps, and *Phylloporina* spp. to the *Myrtaceae*.

The following tentative conclusions seem worthy of record as providing working hypotheses and a basis for further record:—

(1) The habitatal requirements of epiphyllous lichens must be considered in two groups— (*a*) the conditions offered by the leaves themselves, including their life-history, physical, anatomical and constitutional features: (*b*) the outer environmental factors, especially intensity of light, wind and humidity.

(2) The species of supporting plant is not purely accidental, though certain lichens have a wider range of hosts than others. This may not apply to Fitting's third group. The incidence of the species *Physcia* at Kitchener Park appears to depend on a moderate degree of humidity, moderate shade, and relatively persistent leaves on the host plant. But species otherwise favourable to lichen development may be free owing to an unfavourable outer environment, *e.g., Myrtus bullata* is free if the insolation is too strong. Certain genera with apparently suitable leaves do not appear to develop lichens, *e.g., Hoheria, Griselinia, Pittosporum, Coprosma, Rhipogonum.* The reason may lie in their constitutional characters.

(3) Leaves of relatively short-life may be attacked, but for full development of epiphylls a certain persistence is required. Leaves of *Alectryon excelsum* and *Beilschmiedia tawa* often show light attack by *Strigula africana* towards the end of the first growing season, this being as true of seedlings as of adult plants. The leaves are more and more covered till at leaf-fall, which does not appear to be hastened, the surface may be completely covered. The lichen may fructificate on dead, fallen leaves where the ground is dry. A considerable degree of humidity favours the early establishment of lichens. This is aparently especially important in filmy ferns, lichen-attacked leaves being first more or less covered with bryophytes.

(4) The lichens appear 'o inflict little real damage, as seedlings survive and older trees appear to be as vigorous as those free from attack.

(5) Great wettability of surface does not appear to be required, nor is a ready run-off of water of any moment.

(6) A certain optimum of light-intensity is required for full lichen-development. Leaf-lichens are very rare in the deepest shade, and in the fullest sun, with marked development in moderate shade. This is seen well in plants of the forest floor, and in leaves of the shrub-layer. As the tree is ascended the lichen development decreases to the vanishing point. Juvenile *Nothapanax crassifolium* is generally strongly attacked, while the adult is rarely so. There is in general a distinct belt of major attack.

(7) Considerable humidity favours attack. Margins of pools in the forest-interior show a more or less marked lichen girdle. Shade and humidity tend to be associated, but humidity cannot prevail over the effect of deep shade.

(8) Strong wind is apparently prejudicial to lichen attack, but its effect is not always easy to disentangle from that of insolation. As a result of both factors, marginal plants are less attacked than those more protected.

(9) The epiphyllous lichens form more or less distinct communities, this being aided apparently by the different environmental requirements of the lichens. Humidity favours *Lopadium*, and shade with less humidity *Strigula*. Leaves subject to much drip from above will be covered with *Lopadium*. *Bacidia* appears on juvenile leaves of podocarps in the shrub-layer, associated with *Lopadium*. *L. subcaerulescens* is the most frequent lichen on *Beilschmiedia tawa*, and may form pure communities. *Strigula africana* may also form pure communities on *B. tawa*, but where the two lichens occur together *S. africana* is dominated and suppressed. On *Alectryon excelsum Strigula africana* is much the more common lichen, but here too it may be suppressed by *L. subcaerulescens*.

LITERATURE CITED.

ALLAN, H. H., 1923. The Forest Remnants in the Neighbourhood of Feilding. *Rep. Aust. Ass. Adv. Sci.*, vol. 16, p. 402 *ff*.

COCKAYNE, L., 1926. *Monograph on the New Zealand Beech Forests.* Part 1., Wellington.

FITTING, H., 1910. Über de Beziehung zwischen den epiphyllen Flechten und den von Ihnen bewohnten Blättern. *Ann. du Jard. bot. de Buit.*, 3rd supp., 2nd pt., p. 505 *ff*.

FUNFSTÜCK, M., 1926. *Lichenes: Die Naturlichen Pflanzenfamilien.* 8. Band, p. 11. Leipzig.

Hochstetter, F., von., 1863. *New-Seeland.* Stuttgart.
Jennings, A. V., 1896. On two new species of Phycopeltis from New Zealand. *Proc. Roy. Irish Acad.*, 3rd ser., vol. 3, No. 5, p. 753 *ff.*
Schimper, A. F. W., 1903. *Plant-Geography upon a Physiological Basis* (Trans. W. R. Fisher). Oxford.
Shreve, F., 1914. The Direct Effects of Rainfall on Hygrophilous Vegetation. *Journ. Ecol.*, vol. 2, No. 2, p. 82 *ff.*
Smith, A. L., 1921. *Lichens.* Cambridge.
Ward, H. M., 1884. Structure, Development and Life-History of a Tropical Epiphyllous Lichen (*Strigula camplanata* Fée.). *Trans. Linn. Soc.*, vol. 2, pt. 6, 2nd ser., Bot., p. 87 *ff.*
Warming, E., and Graebner, P., 1918. *Eug. Warming's Lehrbuch der ökologischen Pflanzengeographie.* Berlin.

B. TAXONOMIC (A. Zahlbruckner).

Strigulaceae.

1. **Phylloporina** (sect. *Segestrinula*) **rufula** (Krmphbr.) Müll. Arg., Lich.. Epiphyll. Novi, 1890, p. 21, et in *Flora,* vol. 73, 1890, p. 196; A. Zahlbr., *Catal. Lich.*, vol. 1, p. 532.—*Verrucaria rufula* Krmphbr. in *Nouv. Giorn. Bot. Ital.*, vol. 7, 1875, p. 53.—*Porina rufula* Wain., *Étud. Lich. Brésil,* vol. 2, 1890, p. 227.

On the leaves of *Myrtus bullata.*

2. **Phylloporina** (sect. *Sagediastrum*) **cerina** A. Zahblbr. nov. spec.

Thallus epiphloeodes, vix visibilis, maculas minores formans, valde tenuis, substrato quasi suffusus et quoad colorem ab eo vix diversus, virens, opacus, continuus, in margine non bene limitatus, sorediis et isidiis nullis; gonidia phycopeltoidea. Apothecia sessilia, minuta, 0.2-0.5 mm., lata, dispersa, approximata vel confluentia, convexa, ad basin non constricta, ceracea-lutea, nitidula, poro haud conspicuo; excipulum dimidiatum, tenue, pallens (lutescens), a thallo tenuiter obductum, poro terminali, rotundo, 18-20 mmm. lato; nucleus decolor, purus, J. lutescens, imprimis asci; paraphyses increbrae, capillari-filiformes, simplices, eseptatae, ad apicem non latiores; asci oblongo-fusiformes, angusti, subrecti vel curvuli, ad apicem rotundati et membrana parum incrassata cincti, 8 spori; sporae in ascis biseriales, decolores, fusiformi-oblongae, utrinque rotundatae, rectae vel curvulae, 4 loculares, septis valde tenuibus, membrana tenui cinctae, 16-20 mmm. longae et 4-5 mmm. latae.

On the leaves of *Metrosideros Colensoi.*

3. **Strigula africana** Wain. in *Catal. Welwitsch Afric. Plants,* vol. 2, 1890, p. 461.

Frequent on the leaves of *Beilschmiedia tawa, Alectryon excelsum.*

Arthoniaceae.

4. **Arthothelium vermiferum** A. Zahlbr. nov spec.

Thallus epiphyllus, tenuissimus, substrato adhaerens, vulgo maculas parvas, ad 4 mm. latas, monocarpicas formans, apothecia annulatim cingens, demum rare approximatas, haud confluentes, virenti-albidus, opacus, KHO—, Ca Cl_2O_2—, continuus, laevigatus, sorediis et isidiis non praeditus, in margine obscurius non cinctus, sed bene limitatus; homoeomericus, ex hyphis tenuissimis, intricatis

et gonidiis ad Trentepohliam pertinentibus formatus, cellulis gonidiorum luteo-viridibus vel subaurantiacis, concatenatis et glomeratis, plus minusve oblongatis, 12-24 mmm. longis. Apothecia exigua, 0.1-0.18 mm. lata, obscure fusca vel nigricantia, opaca, rotunda vel rotundata, planiuscula, adpressa, emarginata; excipulum distinctum non evolutum; hymenium superne pallide cinnamomeo—vel umbrino—fuscescens, caeterum decolor et purum, J. vix lutescens; hypothecium angustum, decolor; paraphyses mox gelatinose confluentes, non distinctae; asci late ovales vel ellipsoideo-ovales vel subpanduriformes, superne latae rotundati et membrana bene incrassata cincti, 8 spori; sporae in ascis 4-6 seriales, plus minusve convolutae, vermiculari-subcylindricae, utrinque rotundatae, arcuatae et demum semicirculares, murales, cellulis subcubicis, leptodermaticis, in seriebus superpositis ad 20, in seriebus horizontalibus vulgo 2, membrana tenui cinctae, J. parum lutescentes, 60-80 mmm. longae et ad 8 mmm. latae.

A very distinct species. On the leaves of *Metrosideros Colensoi.*

LECIDEACEAE.

5. **Bacidia** (sect. *Weitenwebera*) **perparva** A. Zahlbr. nov. spec.

Thallus epiphyllus, crustaceus, uniformis, tenuis, submembranaceus, demum facile desquamescens, sordide cinerascens, opacus, KHO—, Ca Cl_2O_2—, continuus subleprosus vel subinaequalis, sorediis et isidiis nullis, in margine linea obscuriore non cinctus, fere homoeomericus, gonidiis cystococcoideis, globosis, laete viridibus, 9-10 mmm. latis (gonidiis aliis non ad lichenem pertinentibus hic inde intermixtis). Apothecia minima, ad 0.1 mm. lata, biatorina, fusconigra, opaca, rotunda, ad basin non constricta, e planiuscula modice convexa, dispersa vel approximata; excipulum dimidiatum, crassiusculum, aeruginoso-fuscescens, ex hyphis intricatis formatum, cum hypothecio aeruginoso-fuscescente (obscuriore) confluens; hymenium superne anguste umbrino-fuscum, non pulverulentum, caeterum decolor et purum, angustum, 30-35 mmm. altum, J. lutescens; paraphyses parum distinctae et increbrae, filiformes, simplices, eseptatae, ad apicem clavatae et obscuratae; asci crebri, ovali-clavati, superne bene rotundati et membrana modice incrassata cincti, 8 spori; sporae in ascis biseriales, decolores, oblongae, rectae, utrinque rotundatae, 4 loculares, septis valde tenuibus, membrana tenui cinctae, 11-12 mmm. longae et 3-5 mmm latae.

On the leaves of *Podocarpus spicatus, P. dacrydioides, P. totara.*

6. **Lopadium Allanii** A. Zahlbr. nov. spec.

Thallus epiphyllus, sat late expansus, parum visibilis, quasi suffusus, maculas rotundatas et plus minusve confluentes formans, lutescenti-virens, opacus, KHO—, Ca Cl_2O_2—, continuus, submembranaceus, in margine linea obscuriore non cinctus, sorediis et isidiis destitutus, trichomatibus nigris superne non ornatus; fere homoeo mericus, ex hyphis intricatis, decoloribus, ad 2 mmm. crassis, leptodermaticis et ex gonidiis pleurococcoideis, globosis, lutescenti-viridibus, 6-8 mmm. latis formatus, hyphae thalli in ambitu thalli dissolutae, plus minusve radiantes, increbre ramosae et passim subreticulatae, non amyloideae. Apothecia biatorina, dispersa,

rotunda, parva, ad 0.3 mm. lata, sessilia, ad basin levissime constricta, demum convexula, ceraceo-lutescentia, parum nitidula; discus angustus, thallo concolor, impressus; margo discum paulum superans, angustum persistens; excipulum angustum, decolor, 15-18 mmm. crassum, dimidiatum, ex hyphis subradiantibus et intricatis formatum, non paraplectenchymaticum; hymenium superne anguste et dilute umbrino-fuscescens, caeterum decolor et purum, J violaceo-coeruleum, 75-80 mmm. altum; paraphyses capillari-filiformes, densae, strictulae, simplices, esceptatae, ad apicem non latiores, gelatinose conglutinatae; asci oblongo-clavati, rotundati et membrana bene incrassata cincti, monospori; sporae decolores, oblongae, utrinque rotundatae, rectae vel subrectae, murales, cellulis numerosis, subcubicis et leptodermaticis, membrana tenui cinctae, 60-64 mmm. longae et 12-14 mmm. latae.

On the leaves of *Metrosideros Colensoi, Alectryon excelsum.*

7. **Lopadium subcoerulescens** A. Zahlbr. nov. spec.

Thallus epiphyllus, maculas minores, usque ad 5 mm. latas, rotundato-irregulares et passim confluentes formans, substratum arcte obducens, tenuissimus, albidus vel soridescenti-albidus, opacus, KHO—, Ca Cl_2O_2—, continuus, laevigatus, granulis non obsitus nec trichomatibus praeditus, sorediis et isidiis nullis, in margine linea obscuriore non cinctus. Apothecia parva, 0.1-0.3 mm. lata, fusconigra vel nigricantia, opaca, sessilia, rotunda, ad basin parum constrictula, e convexiusculo demum convexula; margo tenuis, integer, mox depressus, disco concolor, rare in juventute pallescens; receptaculum extus nigricans; excipulum dimidiatum, molle, crassiusculum, subcoerulescenti-fuscescens, ex hyphis intricatis formatum, gonidia non includens; hymenium superne latiuscule sordido-coerulescens, non inspersum, caeterum decolor et purum, 70-80 mmm. altum, J coeruleum; hypothecium umbrino-fuscescens et demum nigricans, molle, sat angustum; paraphyses graciles, filiformes, ramosae eseptatae, ad apicem non latiores, laxiuscule conglutinatae; asci ellipsoideo-clavati, superne bene rotundati et membrana bene incrassata cincti, monospori; sporae decolores, oblongae, utrinque rotundatae vel in uno apice subangusto-rotundatae, subrectae, murales, cellulis numerosis, subcubicis, leptodermaticis, in seriebus superpositis 16-18, in seriebus horizontalibus 2-7, membrana tenui cinctae, 50-60 mmm. longae et 12-16 mmm. latae.

The most frequent of the epiphyllous lichens. On the leaves of *Beilschmiedia tawa, Myrtus bullata, Alectryon exculsum, Asplenium bulbiferum, polystichum vestitum.*

PHYSCIACEAE.

8. **Physcia crispa** Nyl.

On the leaves of *Beilschmiedia tawa, Podocarpus spicatus.*

9. **Physcia tremens** A. Zahlbr. nov. spec.

Thallus dichotome et sympodialiter laciniatus, radiatim crescens, tenuissimus submembranaceus, substrato arcte adpressus, albidus, KHO—, Ca Cl_2O_2—, laciniis linearibus, primum ad 0.2 mm. latis, planis, plus minusve discurrentibus, in margine subintegris vel leviter sinuato-dentatis, ad apicem parum latioribus, rotundatis vel

subemarginatis, demum latioribus, usque ad 1.5 mm. latis, plus minusve confluentibus et contiguis, superne paulum inaequalibus, sorediis et isidiis destitutus in margine non ciliatus, subtus pallidus, dilute et sordide fuscescens, rhizinis brevissimis et increbris; medulla alba, KHO—. Apothecia non visa.

On the leaves of *Alectryon excelsum, Podocarpus spicatus.*

C. A NEW LICHEN-PARASITE (Karl Keissler).

Chlorocyphella lichenicola Keissler nov. spec.

Receptaculis oblique cupularibus auricularibus, sessilibus, submembranaceis, obscure, aeruginascentibus demum expallescentibus, usque ad 1 mm. longis; hymenio concolore; basidiis?; basidiosporis hyalinis, filiformibus, *apice incrassatis, dense septatis,* primum subcurvis deinde curvatis, saepe *rectangulariter* inflexis, *non spinulosis,* Ca. 25-50 $\times$ 2 mmm.

Hab. Neu-Seeland, in thallo sterili Lichenis ad folia *Myrti bullatae,* et in thallo *Lopadii subcaerulescentis* ad folia *Polystichi vestiti* et *Alectryonis excelsi,* Rain forest, Feilding, leg. H. H. Allan (herb. Mus. hist. nat. Vindob.)

Dieser merkwürdige Flechtenparasit, den ich übrigens auch schon aus China gesehen habe, macht in vieler Beziehung den Eindruck einer *Cyphella,* hat aber nicht kurze runde, ovale oder eiförmige Sporen, wie sie bei dieser Gattung vorkommen, sondern solche von linealer Gestalt und bedeutender Länge. Nach diesem Merkmal passt dieser typus anschienend in die Gattung *Chlorocyphella* Speg.,* beschrieben in *An. Mus. Nac. Buenos Aires* T. 19, 1909, p. 279 (*cfr.* Saccardo, *Syll. fungor.*, vol. 21, p. 424). Spegazzini hat dieses Genus als einen Vertreter der Hymenolichenen beschrieben, indem er der Meinung war, dass der Thallus auf dem die *Cyphella*-artigen Gehäuse sitzen, zu diesem dazu gehöre, das ganze also eine Flechte darstelle. Wenn man aber so wie hier bei *Chl. lichenicola* sieht, dass die Fruchtkörper bald auf sterilem Thallus, bald auf dem Thallus von *Lopadium subcaerulescens* aufsitzen, kommt man zur Veberzeugung, dass die *Cyphella*-artigen Gehäuse nicht als Fruktifikation zu dem Thallus anzusehen sind, sondern dass dieselben auf diesem als Parasiten auftreten. Es dürfte also *Chlorocyphella* Speg. als eine Gattung zu behandeln sein, die nicht zu den Hymenolichenes sondern zu den Flechtenparasiten zu zählen ist. Die einzige von Spegazzini beschriebene Art ist *Chl. subtropica,* von Formosa angegeben. Die von mir aufgestellte Art unterscheidet sich von jener durch die *grünlichen* (nicht weisslichen oder rosagrau gefärbten) Fruchtbecher mit *schiefer* Mündung (ähnlich *Cyphella capula*), und durch die oft *rechtwinklig* eingebogenen dicht septierten, am ende *kopformig, verdickten* Sporen.

In der Farbe und Gestalt der Becher erinnert die neu aufgestellte Art an *C. aeruginascens* Karst. (*cfr.* Sacc. *Syll. fung.*, vol. 9, p. 247) von Wainio an Baumrinde in Minas Geraes (Sitio) gesammelt. Diese wird von Wainio, "Études Lich. Brésil," in *Act. Soc. Faun. Flor. Fenn.*, vol. 7, 1890, pars 2, p. 27, auch für Rio de Janeiro angeben und dort ausdrücklich als Flechtenparasit auf dem Thallus von *Lecidia perpallida* bezeichnet. Karsten gibt kugelige

*Exemplare dieser Gattung habe ich keine in Händen gehabt, aber inzwischen nach Buenos Aires darum geschrieben.

Sporen (allerdings mit Fragezeichen) an. An dem Originalexemplar, welches ich zum Vergleich von Herrn Direktor Elfing in Helsingfors erhielt, warem leider keine solchen zu sehen, was fast den Gedanken nahe legt, dass Karsten auch keine wahrgenommen habe und nur vermutete, dass sie dem *Cyphella* Typus entsprächen. Es wäre nicht undenkbar, dass die von mir aufgestellte *Chl. lichenicola* nur das mit Sporen versehene Stadium von *Cyphella aeruginascens* Karst. darstellt. Zu erwähnen wäre noch *C. foliicola* Wain., "Lich. Philipp. III." in *Ann. Acad. Scient. Fenn.*, vol. 15, nr. 6, 1921, p. 83, auf blattbewohnenden Thallus von *Bilimbia polillensis*, welche nach den langfädigen Sporen gewiss als *Chlorocyphella* (*Chl. foliicola* Keissl.) anzusprechen ist. Von dieser ist *Chl. lichenicola* durch die grüne, nicht blasse Farbe der Receptacula, souie durch das *Fehlen* der an der Innenseite der Sporenkrummung entwickelten, in einer Reihe stehenden *Dornen* verschieden.

Zum Schlusse sei noch bemerkt, falls die Receptacula der *Chl. lichenicola* mit einer gewissen Regelmassigkeit auf *Lopadium*-Thallus vorkommen sollten, man dieselben doch als eine Nebenfruktifikation der Flechten aussehen musste, namentlich dann, wenn es etwa gelingen sollte, Gonidien in den Receptacula nachzuweisen.

[It is thought advisable to add the following Abstract of Keissler's remarks on *Chlorocyphella lichenicola* Keissler nov. spec. This noteworthy lichen-parasite, which occurs also in China, has many resemblances to *Cyphella,* but falls into *Chlorocyphella* Speg. owing to its long linear spores. Spegazzini considered his genus to belong to the Hymenolichens, interpreting the cyphella-like structures as belonging to the thallus on which they occurred. When it is noted that the fruit bodies of Keissler's species occur now on a sterile thallus, now on that of *Lopadium subcaerulescens* it must be concluded that it is parasitic. The only species described by Spegazzini was *Chl. subtropica,* from Formosa. The present species differs in the greenish (not whitish or rosy-grey) fruit-cups with more oblique mouths (similar to those of *Cyphella capula*), and in the thickly septate spores, often bent at right angles, and with thickened head-shaped ends.

In the colour and structure of the cups the new species recalls *C. aeruginascens* Karst., collected by Wainio in Minas Geraes. Wainio records this also from Rio de Janiero, and expressly designates it as a lichen-parasite on the thallus of *Lecidia perpallida.* Karsten gives the spores as globular (with a query). No spores could be found by Keissler on the original specimen, and he thinks it probable that Karsten had not seen any, but had only conjectured that they were of *Cyphella* form.

It may be that *Chl. lichenicola* is a spore-bearing state of *C. aeruginascens. C. foliicola* Wain., on the leaf-dwelling thallus of *Bilimbia pollinensis* with long linear spores, is certainly a *Chlorocyphella* (*Chl. foliicola* Keissel.). *C. lichenicola* differs from this in its green, not pale, cups and the absence of a row of spinous processes on the inner side of the curvature of the spores.

If the receptacula of *Chl. lichenicola* occur with a certain regularity upon the thallus of *Lopadium,* they must be considered as a companion fructification (Nebenfruchtifikation) of the lichen, especially if gonidia are found therein..—H.H.A.]

Botanical Notes, New Species and Varieties.

By H. CARSE.

[*Read before the Auckland Institute 4th October, 1927; received by Editor, 23rd November, 1927; issued separately, 10th August, 1928.*]

1. **Pteris saxatilis** sp. nov.

FILIX *P. macilentae* A. Rich. affinis sed in partibus omnibus minor. Stipes 8-24 cm. longus, tenuis, canaliculatus, flavus, suffuscus, vel purpureus, glaber, infra squamosus. Frondes 10-36 cm. longae, 8-15 cm. latae, ovatae vel lanceolatae, valde membranaceae, 3-4—pinnatae. Rhachis fere filiformis. Pinnae primariae distantes, inferiores 8-18 cm. longae, adscendentes; pinna terminalis 25 mm. longa, segmenta ultima alte et acute dentata, apex saepe laciniatus, sori in segmentorum sinibus positi, brevissimi.

Syn. *P. macilenta* A. Rich. var. *saxatilis* Carse in *Trans. N.Z. Inst.*, 51 (1919) 98.

North Island: North Cape to Franklin County, H. B. Dobbie!, H. B. Matthews!, H. C.: Mahia Pen.: Hawkes Bay, G. O. K. Sainsbury! South Island: Marlborough, J. H. McMahon!

After some years further study of this plant I am convinced that it is very distinct from *P. macilenta.*

2. **Carex diandra** Schrank.

This plant has been collected by Mr. K. W. Allison near Rotorua, about 50 miles north of Lake Taupo, the most northerly habitat from which it has hitherto been recorded.

3. **Hydrocotyle moschata** Forst. f. var. **parvifolia** var. nov.

Planta dense implexa, in partibus omnibus typo minor. Folia 2-5 mm. diam. hispida utrinque±, ut in typo lobata. Flores fructusque cum typo congruenter sed pauciores minoresque.

Forming dense mats. Leaves ± hispid on both surfaces, lobed as in the type form. Flowers and fruit smaller.

This form is so constant in its matted habit and smaller leaves, flowers, and fruit, that I have for some time considered it worthy of varietal rank.

North Island: Mangonui to Waimarino, H. C.

4. **Mazus radicans** Cheesem.

The *Manual of the N.Z. Flora* (1925) 772 gives as North Island localities for this plant " Head of the Wairarapa Valley and Tararua Mountains."

I have specimens from the Rotorua district collected by Mr. K. W. Allison, who writes, "The *Mazus* is not common here, but seems well established, as it grows in at least three swamps here several miles apart."

5. **Coprosma macrocarpa** Cheesem.

As was natural to expect, this plant, hitherto recorded from the Three Kings Islands only, has been noted on the mainland. Mr. H. B. Matthews discovered it over a year ago a little south of Cape Maria van Diemen, and later he and I found it not uncommon in a wood in Tom Bowling Bay, near the North Cape.

6. **Olearia pachyphylla** Cheesem.

This handsome plant, previously known only from the Bay of Plenty district, was gathered some years ago in the Kaweka Range by Mr. B. C. Aston.

FIG. 1.

FIG. 2.

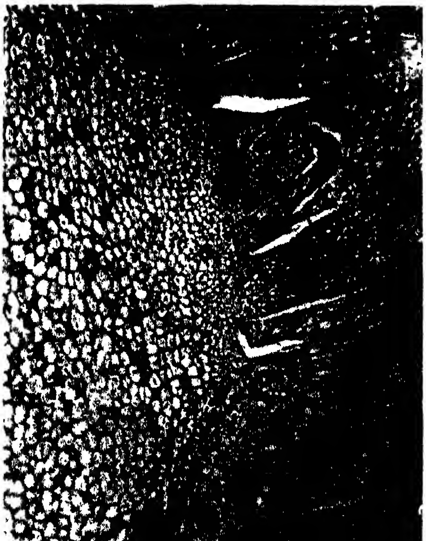


FIG. 3.

FIG. 4.

FIG. 1.—*Melicytus ramiflorus*, longitudinal section through a young stem showing a group of young buds on the side.

FIG. 2.—*Melicytus ramiflorus*, cross section through a stem similar to that in Fig. 1.

FIG. 3.—*Melicytus ramiflorus*, young bud (in June) surrounded by half-dead scale-leaves.

FIG. 4.—*Melicytus ramiflorus*, October. Three little stelar systems are seen in cross-section.

FIG. 5.

FIG. 6.

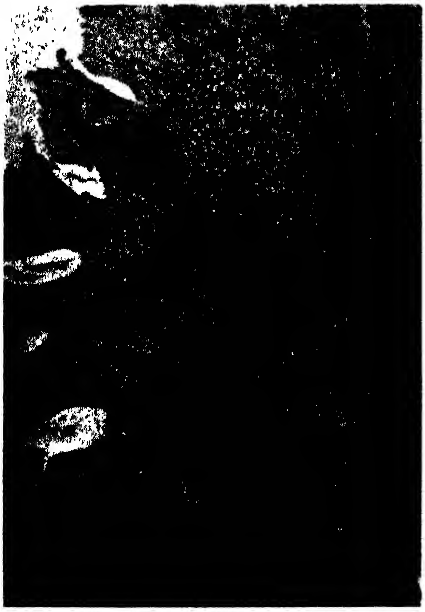


FIG. 7.

FIG. 8.

FIG. 5.—*Melicytus ramiflorus*, longitudinal tangential section through the stele of the stunted branch.

FIG. 6.—*Melicytus ramiflorus*, longitudinal section through a little branch showing its stele in longitudinal section.

FIG. 7.—*Melicytus ramiflorus*, longitudinal section through the stem showing the stele of the stunted branch.

FIG. 8.—*Melicytus ramiflorus*, young buds on old wood, separate fibro-vascular strands are seen passing in to the old stem stele.

Cauliflory.

By ELLEN PIGOTT, M.A., Biological Laboratory, Victoria University College, Wellington, N.Z.

[*Read before the Wellington Philosophical Society, 23rd November, 1927; received by Editor, 26th April, 1928; issued separately, 10th August, 1928.*]

PLATES 46-47.

IT has long been known that certain trees and shrubs bear flowers on their woody parts and not, where flowers would be expected, on young branches and in the axils of existing foliage leaves. Buds normally arise from groups of meristem cells which have been left behind in the axils of the leaves.

Schimper (*Plant Geography,* English Translation, 1903, p. 336) noted cauliflory (stem-flowering) and associated it with thin-bark characters. He says it is caused by dormant axillary buds becoming further developed after several or many years. He points out that cauliflory is much commoner in tropical plants than in plants growing in cold and temperate regions. Tropical plants usually have thin bark whereas temperate and cold-loving plants frequently have stringy bark, and among them cauliflory is rare. He suggests that trunk-flowers are well protected from torrential rain and from excessive heat.

Whitford ("*The Vegetation of the Lamao Forest Reserve,*" 1, 2, *Philippine Journal of Science,* 1906, 1, Nos. 4 and 6) also notes cauliflory as being very common, but gives no explanation. Buscalioni claims that the caulifloral habit is a primitive one, and that it persists in plants of hot, moist regions. Others associate it with the conditions of pollination. Wallace (1891, *Natural Selection and Tropical Nature,* p. 244) noted cauliflory in *Polyalthea* (The Custard Apple family) and in the cacao tree, and suggested butterfly-pollination as an explanation of the phenomenon. However, this is not determined, for *Theobroma cacao,* the chocolate tree, is either self-pollinated or pollinated by insects other than butterflies.

Warming (*Ecology of Plants,* 1909, p. 343) gives a list of caulifloral species, and examples are found in the families Myrtaceae, Sapotaceae, Leguminosae; in many species of *Ficus,* of *Swartzia,* and many others.

Whitford (*Philippine Journal of Science,* 1906, 1. No. 4, p. 423) says, "The ecological advantages are numerous. In many cases heavy fruits are produced which, if not attached to a strong woody stem, would be easily broken off. Such is the case in many Meliaceae, where the fruits often become very large, and where grouped on one stem, very heavy. *Ficus minahassae* has a fruit stalk which is often three metres in length and thickly covered with fruit. No small twig could possibly support such a weight."

In New Zealand there are many trees and shrubs which regularly produce flowers and sometimes slender foliage-stems on woody

branches more than a year old. The disposition varies according to the species; for instance, in *Melicytus ramiflorus* Forst. and *Suttonia australis* A. Rich. the flowers appear on young woody branches just below the crown of leaves, and are very small. In *Hymenanthera crassifolia* Hook. f. they appear anywhere on the old branches and are not grouped closely together. *Fuchsia excorticata* Linn. f. also bears flowers on woody branches, both old and young, but there seems no

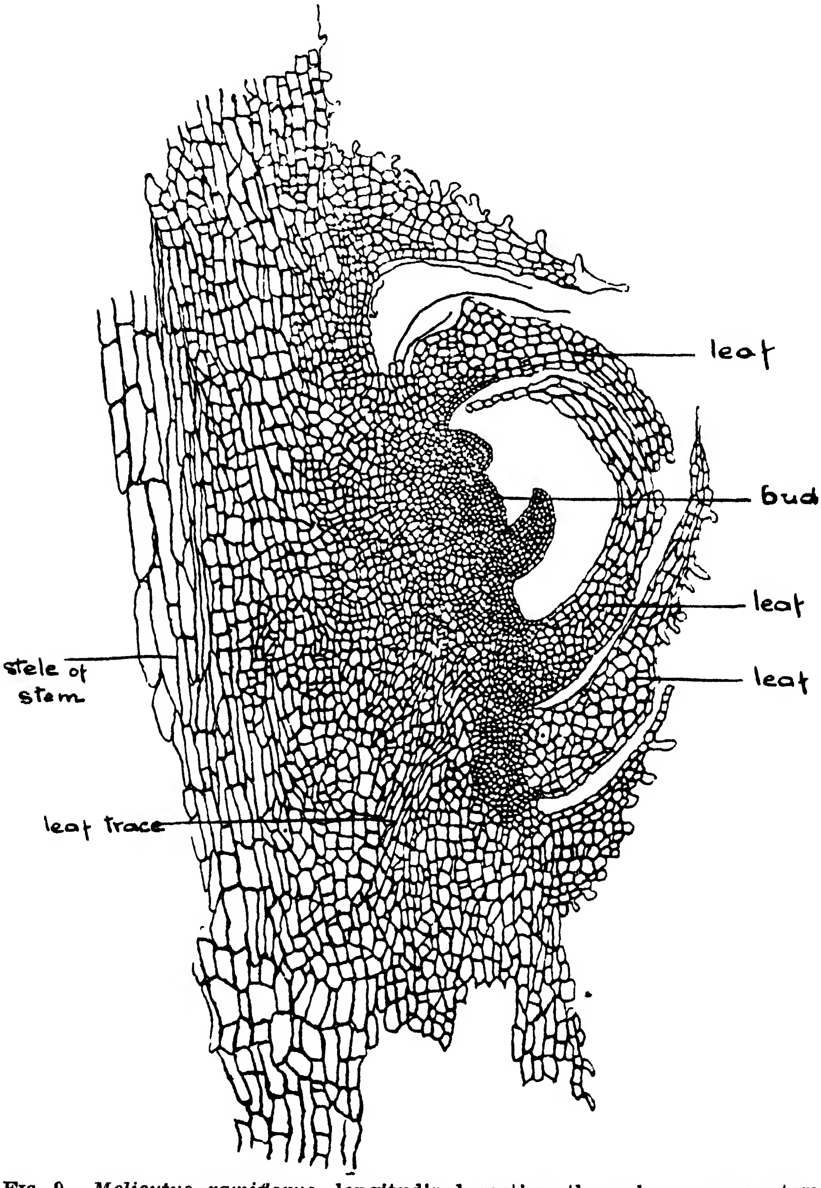


Fig. 9.—*Melicytus ramiflorus*, longitudinal section through a young stem, showing a first group of young buds and leaves.

order in their production. They appear in little groups scattered irregularly over the branches.

The most noticeable of all is *Dysoxylum spectabile* Hook. f., one of the family Meliaceae, which bears all its flowers on the trunk, far away from the leaves and younger branches. Here the flowers are formed, year after year, from the same spot on an apparently otherwise inactive trunk. The flowers are white, somewhat larger than lilies of the valley, and the ripe fruits are the size of a small walnut and very heavy, borne on a raceme about six to twelve inches long.

For work on this subject the five plants above mentioned were examined and a marked similarity in bud-production was discovered.

Taking the case of *Suttonia australis* and *Melicytus ramiflorus*, it is observed that when a leafy branch is formed no flowers are produced on that branch during the first season. By the end of the season most of the leaves have dropped off, and when growth begins in the second season little groups of flowers appear just above the scars of the fallen leaves. If this were all that happened there would be nothing so very noticeable. The little groups of flowers could very easily be accounted for as having sprung from typical meristem which had lain dormant for a season. The fact that calls for attention is that in the following season fresh groups of flowers spring from these same places which have already borne flowers.

To examine the material, sections were taken through young stems of *Melicytus ramiflorus*, *Suttonia australis*, and also of *Melicope ternata* Forst. before the first annual ring had begun to form, that is during the first growing season. Just above the scar of a fallen leaf a little group of buds is found, four or five to each group, each little bud subtended and overarched by little scale-leaves, one or more for each bud (Figs. 1, 2). In *Melicytus ramiflorus* and in *Melicope ternata* the whole group forms an excrescence on the stem just at that spot; in *Suttonia australis* the group is flush with the surface, and the epidermis of the stem only slightly disturbed.

These groups of flower-buds remain dormant until the following spring, when they develop and open out on the stem below the crown of new leaves; except that during the first season in *Melicope ternata* flowers are borne in the leaf-axils as well.

Sections taken later in the season after flowers have dropped off will show the original leaf-scar and also the scars made by the fallen flowerstalks. The subtending scale-leaves die, and if they were not so completely submerged, but were exposed to the wind and weather, would most likely all fall off. As it is, often only the upper half of a scale-leaf falls off and sometimes not even this. At this stage, to a casual observer, in the autumn, the stem would appear to have no life in it; only the epidermis appears a little broken and uneven. All the same, meristem groups are there, mainly seen in the axils of some of the scale-leaves which have not fallen off. These groups are very small, but when the time comes, very active. If the sections are made from material gathered in late summer or very early autumn meristem cells are also found at the bases of the scale-leaves (Fig. 13, m)—their growing regions (Fig. 3). However, these cells cease to be meristematic as the season advances. Also, at the bases of fallen flower-stalks there are often found cells having all the appear-

ance of meristem-cells; these never have been the growing point of a flower-stalk.

Melicytus ramiflorus and *Suttonia australis* often do not set any seed, but the dead flower-stalks persist as late as July. They can easily be knocked off at a slight touch, and the microscope shows, in the axils of the scales, meristem-cells already actively dividing and forming next season's buds. There seems no reason why such a pro-

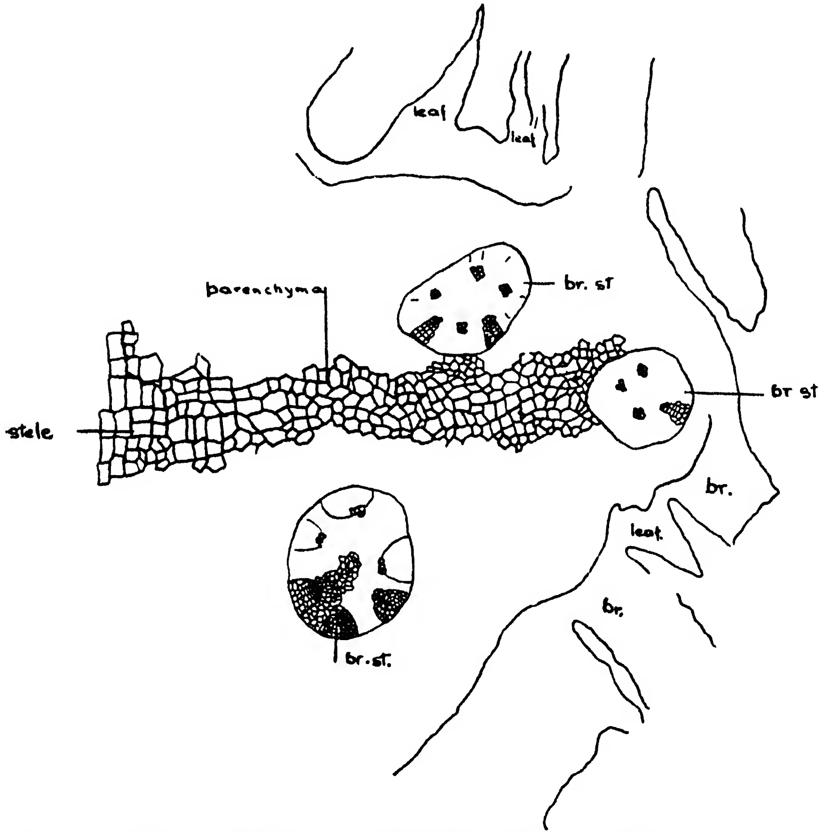


FIG. 10.—*Melicytus ramiflorus*, longitudinal section through the stem near the edge of the stunted branch, showing three steles, each belonging to a small branch.
br. st. = branch stele; l. = leaf.

cess should not be repeated year by year, and this is apparently what actually does occur. New flower-buds are formed, and in the second season they are more in number than in the first, due to the larger number of scale-leaves possessing meristem in their axils; although possibly not all the buds formed develop as flowers that same reason. Each new flower terminates a little branch and has its own scale-leaves (Fig. 2, x), each of which may be provided with meristem capable of developing the following season. The fact that cut stumps of these and other trees are known to send out new shoot points to the fact that some of these groups of meristem in the normal life of the plant fail to develop, but may be stimulated in after years by injury.

In *Melicytus ramiflorus* and *Suttonia australis* flowers usually appear on woody branches of two or three years' growth, but not on the older branches; in *Dysoxylum spectabile* it is the rule that they appear on the trunk and not on the younger branches. In *Melicope ternata* flower-branches appear in the normal position, in the axils of the leaves of young branches, and the branches which appear regularly lower down are foliage-branches, but the explanation of their origin and development is the same for all.

ANATOMY.

First season—Consider the case of *Melicytus ramiflorus.* Sections cut through any stem will show different arrangements of the tissues according to the age of the stem. If the sections are cut during the first season there will be found a set of buds (Fig. 1) or sometimes only one (Fig 9), each overarched by scale-leaves of which there may be as many as five or six to each bud. If there is one bud

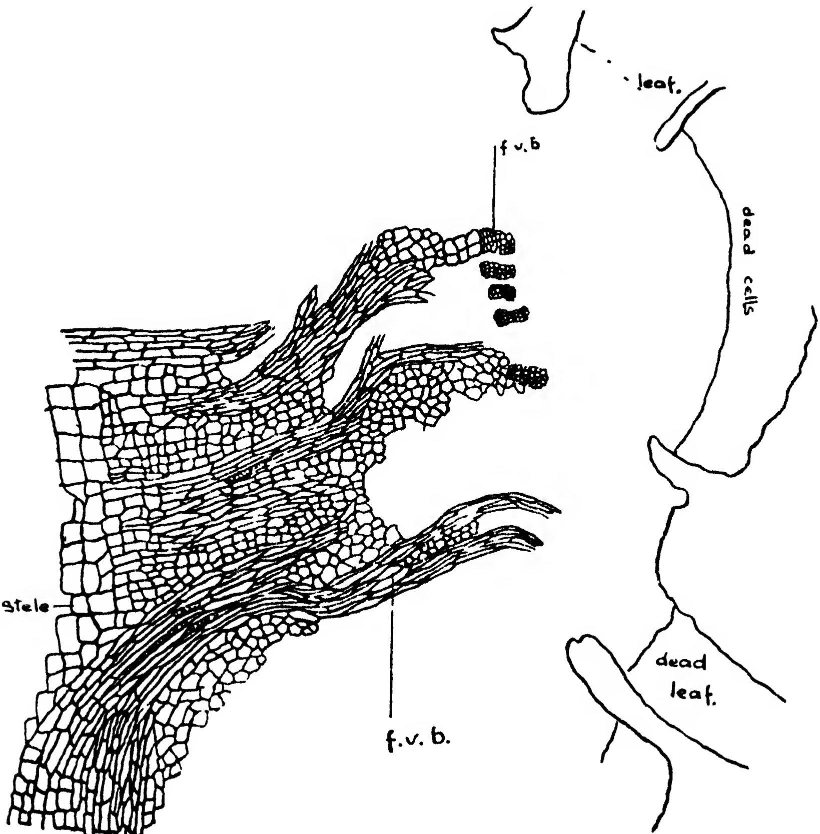


FIG. 11.—*Melicytus ramiflorus,* longitudinal section through a stem of two or three years' growth showing fibro-vascular strands (f.v.b.) from the stunted branch connecting separately with the main stele.

it forms certainly the apex of the excrescence. If there are more the two largest scale-leaves are connected by vascular tissue with the stele of the stem (Fig. 3), and in some cases this vascular tissue is very feebly developed indeed, consisting of a row of two or three weak vessels and a few other ill-defined thin-walled elongated cells. None of the other scale-leaves show any vascular tissue whatever, nor as yet do the little buds. This whole group of buds and scale-leaves is seated on a cushion of parenchymatous cells, small in size, which has evidently been formed from the meristem, so that the group is very slightly beyond the level of the epidermis. (In *Suttonia australis* this cushion is absent).

As growth continues the buds develop; each one forms a little branch, terminated in a flower, and bearing more scale-leaves. Each branch develops a vascular system containing from four to seven little bundles (Figs. 10 and 4) and the cells of the vascular system are often so weakly developed that careful staining is necessary in order to see them at all. The bundles strike obliquely across the parenchymatous cushion at its base and bend downwards to the stem-stele (Figs. 11 and 5). Longitudinal sections at this stage will also show the bundles from the two largest scale-leaves striking inwards and downwards towards the stele of the stem.

There appears to be only one strand from each leaf. The strands from the scale-leaves and some of the bundles from the little branch, that is, those that are on the same side, join one another or nearly do so at their bases just where they are inserted on the stele.

Cross-sections of stems of similar age taken about the same time, that is in June or at any time before the spring, will show the vascular system of the little branches striking immediately in to the stem-stele. If there is only one little branch the arrangement is simple. If there are several branches the little branch nearest the outside, that is the lowest, sends part of its stele to the main stele, and part to an adjacent little branch and so on all around the excrescence (Figs. 12 and 6). The little branches nearer the centre of the excrescence send their strands to one another. The scale-leaves are so small that it is difficult to detect their vascular bundles, and it is certain that many of them never possess any.

The whole group of little flower-branches with their subtending scales is to be regarded as constituting one branch, very much stunted, so much so that it rises very little above the epidermis of the stem. (In *Suttonia australis* it does not rise at all, but is flush with the surface.) It consists for the most part of small parenchymatous cells, which develop from the meristem of the buds (Figs. 9 and 8) and of the leaf bases. It is traversed near its circumference by vascular bundles from the little flower-branches, and these bundles follow a very irregular and uneven course. Each little flower-stalk has its own stele consisting of from four to seven bundles with very little medulla (Fig. 4), which unite further in to form the stele of the stunted branch; (Figs. 13 and 7) this therefore contains a large number of bundles, twenty or more, which although they lie close together, side by side, do not unite. In other words there is no interfascicular cambium. This stele forms in cross-section a wide ring with a very large pith, and the bundles insert themselves separately on the old stem stele (Figs. 8 and 11).

Second season. The little flowers drop off, and the apex of the stunted branch has disappeared. However, new growing-points arise in the axils of some of the scale-leaves. By the activity of some of these groups of meristem the stunted branch increases in size, but instead of elongating, it spreads, forming on the surface of the old stem an irregularly-shaped excrescence. It seems certain that these meristem-cells together with the meristem-cells at the bases of the scale-

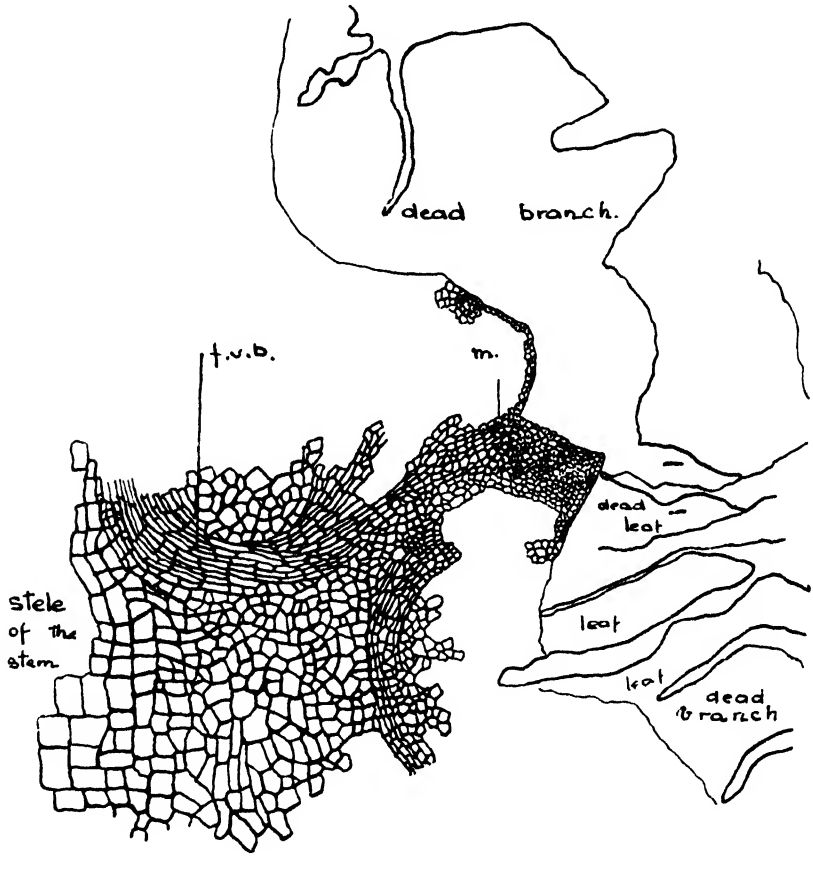


FIG. 12.—*Melicytus ramiflorus*, longitudinal section through the stem showing stele of a small branch, also in longitudinal section; one side (f.v.b.) connecting with main stele and the other side running to stele of the adjacent small branch.
l. = leaf. m. = meristem.

leaves help to increase the bulk of the parenchymatous cushion found in *Melicytus ramiflorus.* Of course the meristem of the leaf-bases is most active while the leaves are young. New flower-branches arise, each with its own set of scale-leaves, and each with it own stele. The scale-leaves seem to have no vascular tissue and the new branch-stele joins up with the stele of the stunted branch. If the stunted branch were allowed to increase in size in this way and there were no other factor to be considered it would form an excrescence gradually in-

creasing in size on the side of the stem. In *Melicytus ramiflorus* this almost seems to take place, but in such a tree as *Dysoxylum spectabile* rapid growth in thickness and increase in diameter of the trunk takes place, and tends to keep the short lateral branch submerged.

After it has been originated, further growth of such a stunted branch may in the first place be accounted for by the weak development of vascular tissue, both of the scale-leaves and of the first little bud-rudiment or rudiments, the cells of the xylem and phloem being

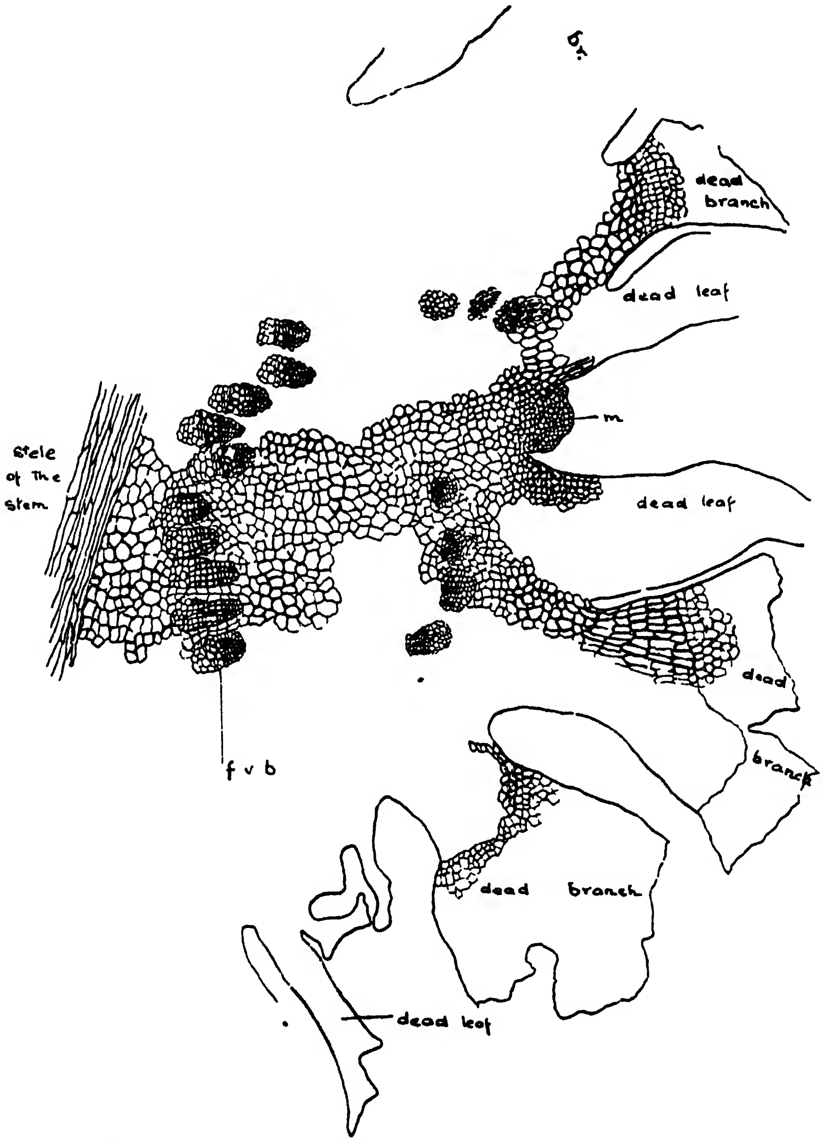


FIG 13.—*Melicytus ramiflorus*, longitudinal section through a stem of several years' growth showing the stele of the stunted branch.

too small to carry food-material sufficient for the construction of a strong branch. Also, the absence of interfascicular cambium and the very doubtful presence of fascicular cambium prevents any growth in thickness of the stunted branch or any increase in the number of xylem and phloem cells.

The fully-developed stele of a stunted branch is very unusual in shape. It never forms a cylinder such as is found in any elongated stem, but it has instead the form of an incomplete disc, following the contour of the excrescence. Since there is no interfascicular cambium, secondary growth does not take place. The identity of the original bundles can be easily recognized; in some places they are closer together than in other places; and if, half way down the stunted branch they seem almost to be united, they are seen to widen out again lower down.

Cork forms at the bases of the scale-leaves and flower-stalks as they die or drop off, so that there is also a disc-shaped region of cork, incomplete, just outside the stele.

LEAF-GAP.

The original leaf-gap made in the stele is very wide. It is occupied during the first season by large almost square parenchymatous cells, four or five times as large as the parenchymatous cells of the cushion outside it. These cells are thin-walled, with obvious nuclei and much protoplasm. During the growth of the stem they thicken and harden but do not alter much in shape. Thus it is always easy to tell where the leaf-gap was originally formed, for the wood-cells adjacent are long narrow cells. The cortex of the main stem just outside a leaf-gap consists of large cells like all other cortical cells of the plant except the very small cells of the parenchymatous cushion of the stunted branch. These, as was stated above, have arisen from the very small meristem-cells at the several growing-points of the stunted branch, and correspond to the medulla and cortex of the stem. It is therefore very easy to tell where the cortex of the main stem ends and the parenchyma of the lateral stunted branch begins.

In a stem of three or four years' growth the cells filling the gap are not quite so square in outline. Their longer axes are at right angles to the long axes of the wood-cells, and when they are thickened equally with the wood-cells the whole mass filling the gap can be pulled out, giving at first a false idea that they may be a foundation for the whole lateral stunted branch.

For valuable help and advice in the preparation and arrangement of this paper I wish to thank Professor Kirk.

On the Occurrence of the Silver Southern-Beech (*Nothofagus Menziesii*) in the Neighbourhood of Dunedin.

By G. Simpson and J. Scott Thomson.

[*Read before the Otago Institute, 9th August, 1927; received by the Editor, 16th May, 1928; issued separately, 17th August, 1928.*]

Plates 48-51.

1. General.

A question of considerable moment in plant-geography is the occurrence of species which, though common enough elsewhere, are most limited in numbers in some particular locality.

The forest in the neighbourhood of Dunedin (South Otago Botanical District) supplies several interesting problems of this class, one of which, to be considered here, deals with that fundamental matter concerning New Zealand forests in general—the relation between subtropical forest composed of broad-leaved dictotylous trees and podocarps, and subantarctic forest where one or more species of *Nothofagus* dominate.

As will be seen further on, there are in the Dunedin area some twelve pieces of *Nothofagus Menziesii* forest, mostly quite small, indeed, out of all proportion to the original forest-covering of the area, and the question at once arises, "Is the silver southern-beech (*N. Menziesii*) a new arrival, or is it merely a survivor of a former host?" To attempt an answer to this important question is the main object of this paper. Secondary to this is the presentation of various matters referring to these Dunedin *Nothofagus* communities, and especially the placing on record of their distribution and composition.

Finally, in the light of our new knowledge concerning *Nothofagus* in the Dunedin area, we are in a position to examine critically L. Cockayne's bold theory (1921: 322-23 and 1926: 39) regarding the relation between the two great classes of New Zealand rain-forest—the subtropical and the subantarctic.

The said theory is based on the present latitudinal, altitudinal, and ecological distribution of *Nothofagus* forest in New Zealand, and it suggests that at one time the *Nothofagus* forest was the chief tree-community; but that it has been gradually replaced by the subtropical forest of Malayan origin, the *Nothofagi* having been slowly suppressed where the soil is comparatively fertile, and that the *Nothofagus* forests could only remain intact on the poorer ground or at higher altitudes where the climate is hostile to a majority of the subtropical forest species.

At the time of the settlement of Otago there can have been at no place near Dunedin any considerable area of *Nothofagus*. The whole of the slopes on both sides of the harbour were covered with dense subtropical rain-forest*; that on the west stretching from

*Hereafter cited as rain-forest, but it must be remembered that rain-forest in New Zealand includes both the subtropical and subantarctic forests.

the water's edge to the high ridges of Mount Cargill and Flagstaff Hill and extending northwards to beyond the Waikouaiti River.

With few breaks this forest covered the hills to the west of Dunedin and along the slopes north and west of the Taieri Plain. The gullies to the east of the plain were also thickly forest-clad, and the reserve at Taieri Mouth gives evidence of the once splendid rain-forest which at that time clothed the hills along the coast-line. In this extensive area *Nothofagus Menziesii* has previously been reported from the following places only, the authority for each locality being given in parenthesis:—(1) Ravensbourne, Dunedin Waterworks and West Taieri† (Dunedin Field Club, 1916: 21); (2) near Leith-Waitati Road (Watt, 1924: 674-75); (3) Mount Cargill, above Main North Road (Petrie, 1896: 573).

Exhaustive enquiries among bushmen and others brought to light a few more localities, and field-work has augmented the list, so that to the above we have been able to add the following:—(4) Pigeon Flat (a few trees only), (5) Fergusson Creek (a stand of considerable area in higher forest with remnants also near Leith-Waitati Road, and on south side of Double Hill), (6) Bethune Gully (a mature stand in the midst of rain-forest), (7) Flagstaff Creek (isolated trees along the creek bed), (8) Boulder Hill (stand on the south side of this hill), (9) Traquair Burn, Outram Glen (trees along creek bed, evidently a remnant), (10) Taieri Mouth (remnant of once large stand which has been cut down and milled), (11) Source of south branch of Waikouaiti River, (12) Silver Peaks (an extensive area of pure southern-beech forest).

No doubt other isolated trees or groups of trees are still unrecorded, and at many places they have been cut down. Several such spots have been pointed out to us by settlers,* but as all evidence of their existence is now destroyed their occurrence at these points cannot be accepted for the purposes of this paper.

The above newly-recorded areas were carefully examined, and in several of them the trees were counted, the diameters of their trunks measured, the occurrence of seedlings and saplings noted, and the age of saplings determined by counting their annual rings. Notes were also taken of the composition of the surrounding forest, of the undergrowth immediately under the *Nothofagus* trees and also that of the forest floor-covering, especially with regard to its light-reducing properties.

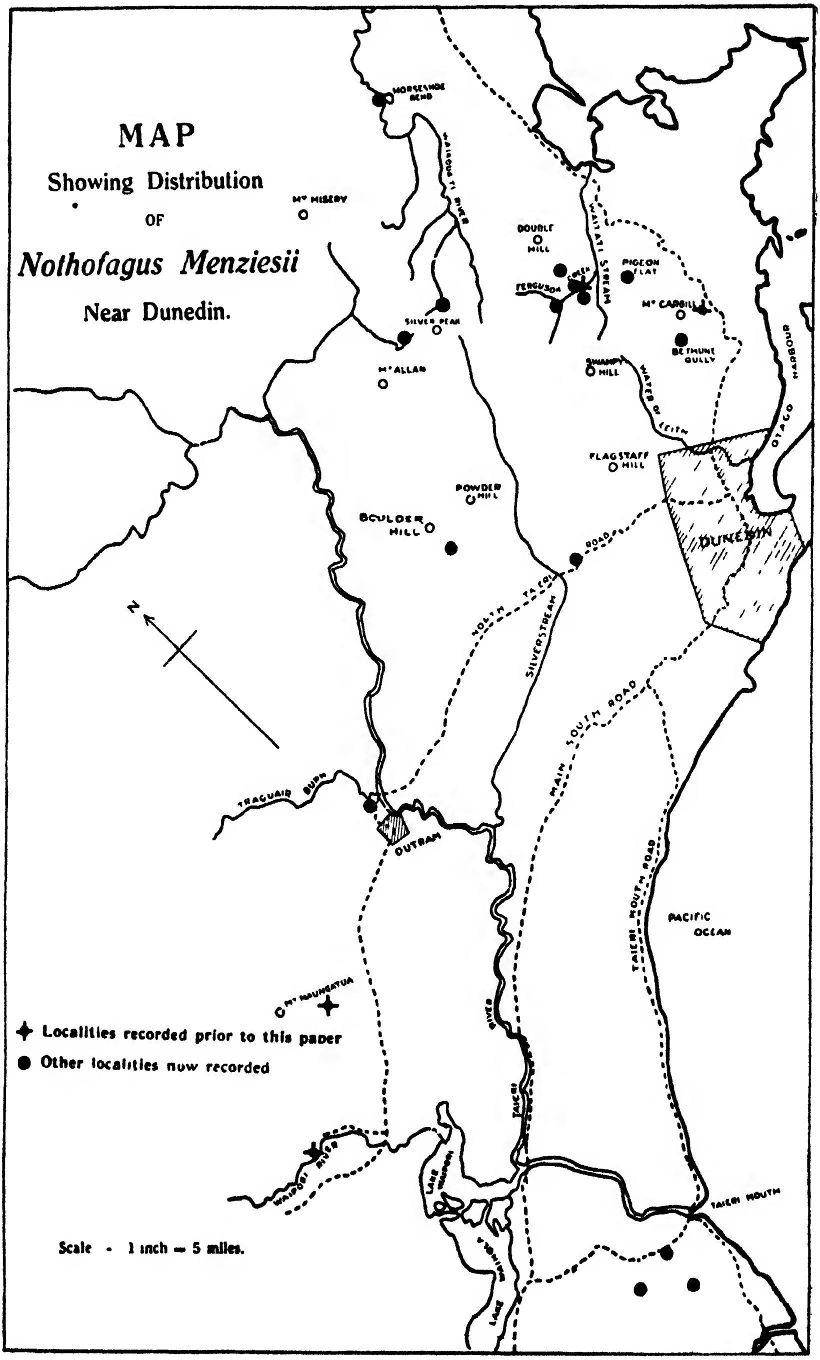
2. THE AREAS KNOWN PRIOR TO THE DATE OF THIS PAPER.

It seems best to deal with each reported area in the order they have been recorded; they are as follows:—

(a) At Ravensbourne and the Dunedin Waterworks (Ross Creek) no traces can now be found, and the trees have evidently been destroyed.

†After West Taieri comes the convenient "etc.," which not merely tells nothing, but is misleading, since it suggests that other areas of *Nothofagus Menziesii* were well known, and that the species was fairly common.

*From experience we find that records of *Nothofagus* by settlers must be received with great caution, since besides species of *Nothofagus* many other trees are "birch"—as they call such—to them.


MAP
Showing Distribution
OF
Nothofagus Menziesii
Near Dunedin.
HORSESHOE BEND
Mt MISERY
DOUBLE HILL
PIGEON FLAT
FERGUSON
WAITATI STREAM
Mt CARGILL
SILVER PEAK
BETHUNE GULLY
Mt ALLAN
SWAMPY HILL
WATER OF LEITH
OTAGO HARBOUR
FLAGSTAFF HILL
POWDER HILL
BOULDER HILL
DUNEDIN
ROAD
NORTH TAIERI
SILVERSTREAM
N
MAIN SOUTH ROAD
TRAQUAIR BURN
OUTRAM
PACIFIC OCEAN
TAIERI MOUTH ROAD
Mt MAUNGATUA
RIVER
TAIERI
Localities recorded prior to this paper
Other localities now recorded
WAIPORI RIVER
LAKE WAIPORI
LAKE WAIHOLA
TAIERI MOUTH
Scale - 1 inch = 5 miles.

(b) That part of the Taieri Plain known as "West Taieri" had a considerable covering of *Nothofagus* which extended from Woodside Glen to Waipori, and included the slopes of Maungatua. Much of this area has been cut over in earlier years and fires have taken their toll, the present forest being mainly that reserved in the Woodside Domain and in the Dunedin City Corporation's Reserve at Waipori. At Woodside *N. Menziesii* occurs along the bed of the stream at about the level of the plain (some 45m. altitude) and runs up the sharper ridges to approximately 200m. At that height it forms a belt extending right along the hillsides above the rain-forest and giving out, at about 600m. altitude, in the valleys dividing up the tussock-clad slopes of Maungatua. Above this belt a thicket of *Leptospermum scoparium* runs up to the scrub-line. Along the edges of the creeks and throughout the rain-forest below the line of the *Nothofagus* forest the following species occur*:—

Alsophila Colensoi, Aristotelia serrata, Asplenium bulbiferum, A. flaccidum, Astelia nervosa var. *sylvestris, Blechnum discolor, B. fluviatile, B. lanceolatum, B. Patersoni* var. *elongatum, B. procerum, Carpodetus serratus, Cassinia Vauvilliersii, Clematis indivisa, Coprosma areolata, C. crassifolia, C. foetidissima, C. linariifolia, C. lucida, C. parviflora, C. propinqua, C. rhamnoides, C. rotundifolia, Coriaria arborea, Cyathea dealbata, Cyclophorus serpens, Dacrydium cupressinum, Dicksonia squarrosa, Fuchsia excorticata, Griselinia littoralis, Hebe salicifolia* var. *communis, Hemitelia Smithii, Leptopteris hymenophylloides, L. superba, Leptospermum ericoides, L. scoparium, Loranthus micranthus, Melicytus ramiflorus, Metrosideros hypericifolia, Muehlenbeckia australis, Myrtus obcordata, M. pedunculata, Nothopanax Colensoi, N. Edgerleyi, Olearia arborescens, Parsonsia heterophylla, Pennantia corymbosa, Podocarpus ferrugineus, P. spicatus, P. Hallii, P. totara, Polypodium Billardieri, P. diversifolium, P. grammitidis, Polystichum Richardi, P. vestitum, Pittosporum eugenioides, P. tenuifolium, Pseudopanax crassifolium* var. *unifoliolatum, Rhipogonum scandens, Rubus australis* var. *glaber, R. cissoides, Suttonia australis, S. divaricata, Tupeia antarctica, Wintera colorata.*

In this particular locality *Edwardsia microphylla* also occurs abundantly. The parasitic *Elytranthe Colensoi* with its beautiful red blossoms and large green leaves covering the branches of the southern-beech is a glorious sight in December and January.

Very little undergrowth occurs in the greater part of the southern-beech forest, but in places opened to the light by falling trees or by the axe, seedling trees and saplings occur in profusion. (Fig. 1.) In the vicinity of streams the forest-floor is covered by various ferns and brypophytes, trees of the undergrowth and shrubs spring up in every open space and, in spots that have been cleared, become so dense that progress through them is almost impossible. *Nothofagus Menziesii* as a fully developed forest-tree here holds its own against all-comers, but its seedlings are quickly suppressed by the aggressive subtropical rain-forest trees and shrubs. The southern-beech seedlings grow vigorously on the drier ridges and slopes, but

*This list, with few exceptions or additions may, to save repetition, be taken as typical for the forest vegetation surrounding and in contact with most of the *Nothofagus* stands listed.

cannot compete in the moist and shaded places with the larger-leaved, fast-growing shrubs and second-layer trees.

The grassland and subalpine scrub above the upper margin of the forest have been repeatedly burned, and fire has cut into the standing trees. The incoming vegetation consists mainly of *Aristotelia serrata, Blechnum discolor, B. procerum, Carpodetus serratus, Dracophyllum longifolium, Griselinia littoralis, Hebe salicifolia* var. *communis, Nothopanax Colensoi, N. simplex, Pittosporum eugenioides, P. tenuifolium,* and *Rubus australis* var. *glaber,* while *Cassinia Vauvilliersii* and *Hebe buxifolia* are dominant in the scrubland together with occasional plants of *Aciphylla Scott-Thomsonii,* and *A. Colensoi.*

Seedling and sapling southern-beeches occur usually on rising ground where the soil is shallow or where the fern is open. *Leptosperum scoparium* sometimes forms dense thickets which contain seedling plants of *Carpodetus serratus, Clematis indivisa, Coprosma rhamnoides, Griselinia littoralis, Nothopanax Colensoi, N. simplex, Parsonsia heterophylla, Pseudopanax crassifolium* var. *unifoliolatum, Suttonia australis* and occasional plants of *Asplenium bulbiferum, Astelia nervosa* var. *sylvestris, Blechnum discolor, B. fluviatile,* and *B. procerum.*

At Waipori the southern-beech forest again follows the stream and spreads along the higher ground while much the same conditions govern forest-rejuvenation. Seedlings are plentiful on the broken debris of the higher slopes, but the trees of the rain-forest close up all open spaces on shaded or lower levels. Wherever fire has destroyed the original plant-covering, a dense scrub of *Leptospermum scoparium* and *L. ericoides* covers the damaged areas. *Corokia Cotoneaster, Edwardsia microphylla,* and *Helichrysum glomeratum* growing on the sunnier side of the gorge, are indicators of fairly dry and free soil. Here, as at Woodside, in midsummer *Elytranthe Colensoi* beautifies the otherwise sombre forest. In places along the sides of the road seedling southern-beeches are quite common but never in competition with the usual second-growth vegetation. The leaves of the southern-beech in this locality are attacked by a species of *Eriophyes.*

(c) The Waitati locality.

A few trees only occur at this spot (approx. 150m. altitude) which are evidently a remnant of a stand long since milled.

(d) The Mount Cargill stand (altitude 425m.).

L. Cockayne rightly supposes (1926: 30) that these trees had "probably gone long ago." The whole of the old trees were milled, and only the old stumps remain, but from these and from the stumps of some second-growth trees, not long ago destroyed, and from an examination of the young trees still left standing, a conclusion as to the extent of the stand and the rate of growth of saplings was obtained.

Many of the stumps are very large and the following measurements, taken June 5th, 1926, show that the original trees were of considerable age.

Original large trees (14 in number) now cut down and burnt, leaving burnt stumps only from which the following mean diameters were taken: (Mean diameters), 68cm., 73cm., 86cm., 96cm., 96cm.,

116cm., 116cm., 116cm., 122cm., 122cm., 137cm., 137cm., 167cm., 167cm. Other stumps still remain but these were too far decayed to afford reliable details.

Mean diameters of trees (second growth) recently cut down (34 in number): (Mean diameters) 5cm., 8.3cm., 8.3cm., 8.9cm., 9.5 cm., 10.2cm., 10.2cm., 10.2cm., 10.2cm., 10.8cm., 10.8cm., 10.8cm., 10.8cm., 10.8cm., 10.8cm., 11.4cm., 11.4cm., 11.4cm., 11.4cm., 12.1cm., 12.1cm., 12.1cm., 12.7cm., 14cm., 14.6cm., 14.6cm., 15.2cm., 17.1cm., 17.1cm., 17.1 cm., 17.8 cm., 19.7 cm., 24.1 cm., 24.1 cm.

Some sixty southern-beech saplings with mean diameters ranging from 2.5cm. to 32cm. still stand in small groups or as individuals usually with a protecting growth of *Fuchsia excorticata,* species of *Coprosma* and *Rubus australis* var. *glaber,* but elsewhere the ground is cleared for grazing and seedling plants are absent. The forest surounding this group on the north and west is composed mainly of *Libocedrus Bidwillii* (dominant at this level and forming an almost pure association as the ground rises), *Podocarpus ferrugineus, P. Hallii, P. totara, Dacrydium cupressinum,* and the usual trees and shrubs of the undergrowth; *Phyllocladus alpinus* is present also *Dracophyllum longifolium* which here attains a large size, some specimens measured being over 25cm. diam. Every indication points to the whole forest being of considerable age, and the *Nothofagus* stand of very limited extent in recent times.

3. AN ACCOUNT OF THE NOTHOFAGUS AREAS NOT PREVIOUSLY RECORDED.

(a) Pigeon Flat (245m. altitude). At this spot only a few trees remain, and little evidence can be obtained to determine the extent of the original stand. The surrounding rain-forest has been cut over time and again, and the largest *N. Menziesii* (106cm. diam.) stands at the corner of a paddock with a wire fencing fastened round its trunk. The fact of *Nothofagus* occurring at this point, however, is important.

(b) Fergusson Creek. Close to where the creek crosses the Leith-Waitati Road, and on both slopes of the gully, *N. Menziesii* occurred in stands of considerable size and tramways were run in many years ago to bring out both the southern-beech and the surrounding forest-trees. Young trees of *N. Menziesii* came up in several places and have reached maturity, but never as a close association. Cattle followed the bushmen, and second-layer trees and ferns crept in, filling up the steeper ground. At present, cattle-tracks lead through this to the flatter land above. Nearer the source of the creek at an altitude of approx. 300m. the forest is dense and, though similar in composition to the forests already mentioned, is much wetter, containing as it does many small streams and hollows which drain Swampy Hill. Species of *Hymenophyllum* grow luxuriantly and bryophytes abound. The lichen vegetation is well developed, and the whole area is exposed to heavy coastal mists. Almost pure stands of *Dacrydium cupressinum* are common, *Leptospermum scoparium* following where the forest has been cleared. Here a *Nothofagus Menziesii* stand occupies an area of about a hectare in extent, closely hemmed in by the rain-forest, and the whole area is densely covered

with second-layer trees and shrubs of which *Coprosma foetidissima* is dominant. The humus covering of the ground is deep and overlaid with liverworts and mosses; young plants of *Nothofagus* are found in a few places, but generally the undergrowth is exceptionally dense; tree-ferns and *Blechnum discolor* cover up all openings in the almost unbroken tangle and *Leptopteris superba* is plentiful. Individual *Nothofagus* trees occur sometimes at considerable distances from one another, but around these individuals, and in the intervening spaces, their seedlings have not developed. Further north, towards Double Hill (altitude about 300m.) a patch of sapling *N. Menziesii* is growing amongst *Leptospermum* scrub, probably seedlings from trees now destroyed.

(c) Bethune Gully. This area of *Nothofagus* is of particular interest in that it stands as an unbroken colony in the midst of a heavy association of rain-forest which commences at an altitude of about 100m. and extends unbroken to near the summit of Mount Cargill. A *Dacrydium cupressinum-Podocarpus ferrugineus* association runs up to approximately 450m. (the level of the *Nothofagus*); *Podocarpus Hallii* comes in as the ground rises and, above the *Nothofagus* (Fig. 2), *Libocedrus Bidwillii* is dominant; *Dacrydium biforme* is present, trees of the undergrowth, mainly species of *Nothopanax* and *Coprosma* occur throughout and tree-ferns are common in the lower forest. Mosses, lichens and filmy ferns clothe the fallen timber and lower trunks of the larger forest trees and *Blechnum discolor* is abundant (Fig. 3) everywhere along with *Nertera dichondraefolia*. *Leptopteris superba* and *L. hymenophylloides* are common while *Polystichum vestitum* occurs in the more open spaces. The forest on the upper ridges has been burnt, leaving skeleton trees and fallen stumps, and through part of this the usual trees of the second-layer have sprung up. The higher ground is fenced for cattle and *Cassinia Vauvilliersii* is the common shrub.

TABLE A.

Number of *N Menziesii* Present	With Mean Diameters Ranging From	Approx Percentage of Total Number of *Nothofagi* present
4	0.5cm.— 2.5cm.	2.4%
6	Above 2 5cm.— 5 cm.	3.6%
14	„ 5 cm.— 7.5cm.	8.4%
17	„ 7 5cm.—10 cm.	10.2%
17	„ 10 cm.—15 cm.	10.2%
13	„ 15 cm.—23 cm.	7.8%
14	„ 23 cm.—30 cm.	8.4%
21	„ 30 cm.—45 cm.	12.6%
15	„ 45 cm.—60 cm.	9.0%
15	„ 60 cm.—76 cm.	9.0%
13	„ 76 cm.—91 cm.	7.8%
7	„ 91 cm.—106 cm.	4.2%
5	„ 106 cm.—122 cm.	3.0%
3	„ 122 cm.—137 cm.	1.8%
3	„ 137 cm.—152 cm.	1.8%
1	„ 167 cm.—182 cm.	0.6%
Total: 168 in the group.		

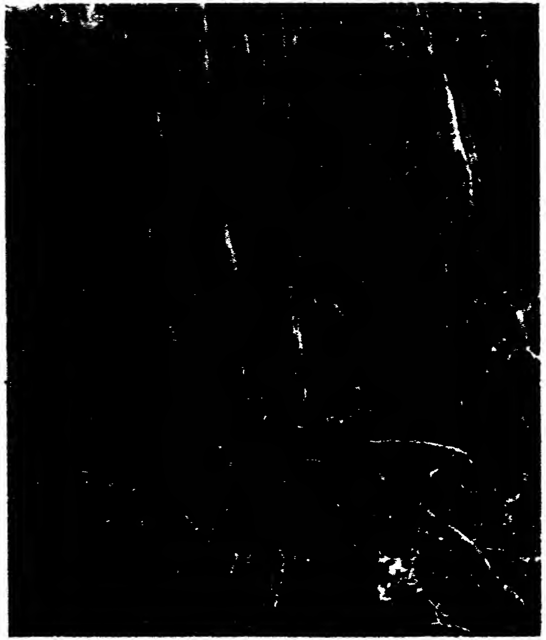


FIG. 1.—Rejuvenation of *Nothofagus Menziesii* on ridge at Woodside where large trees have been felled.

FIG. 2.—*Nothofagus Menziesii* in Bethune Gully, 6.7 metres in circum. at 0.6 metres from ground and 5.3 metres at 1.8 metres from ground. Buttresses at base of trunk.

Fig 3.—Dense growth of *Blechnum discolor* in the Nothofagus community at Bethune Gully which forbids development of seedlings of any kind

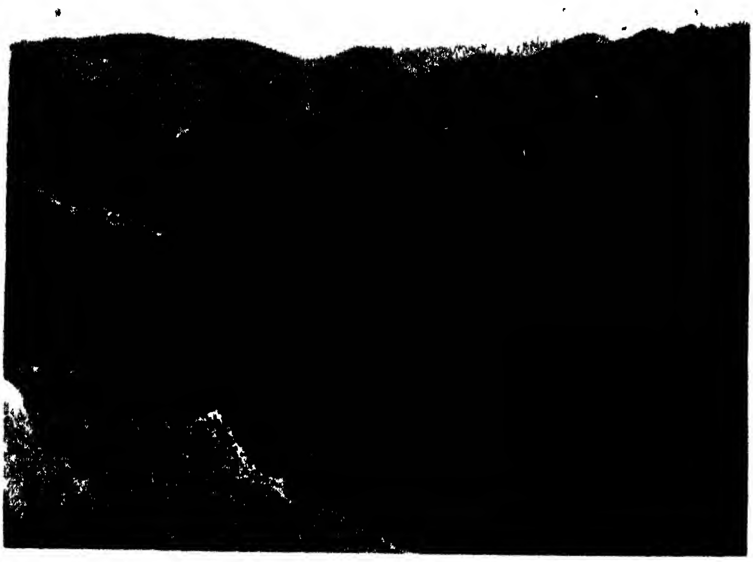


Fig. 4—General view of the Silver Peaks Nothofagus forest, one sq. kilometre in extent.

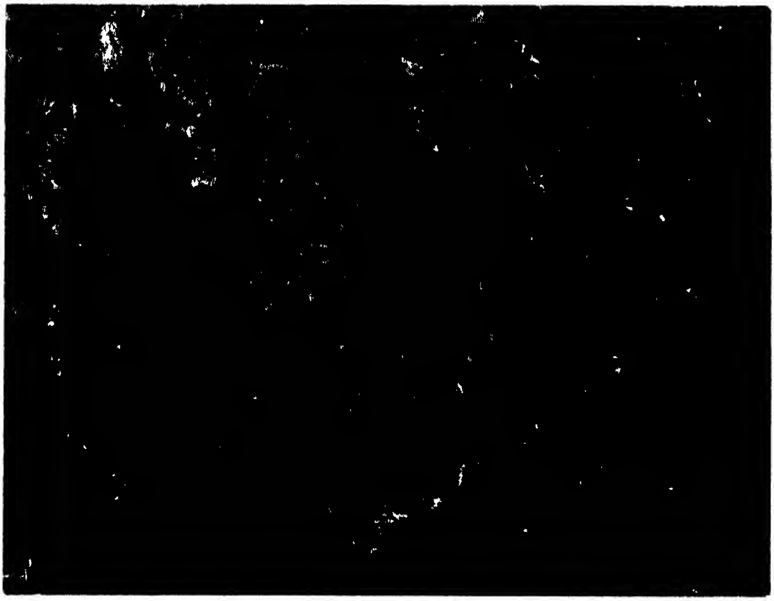


FIG. 5.—*Nothofagus Menziesii* saplings within the Silver Peaks forest.

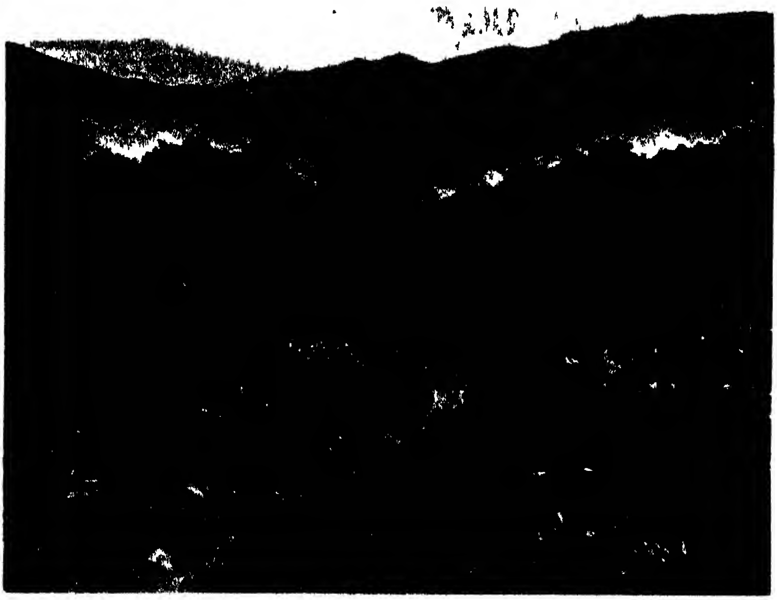


FIG. 6.—Community of *Phormium Colensoi* and certain shrubs at head of Silver Peaks forest.

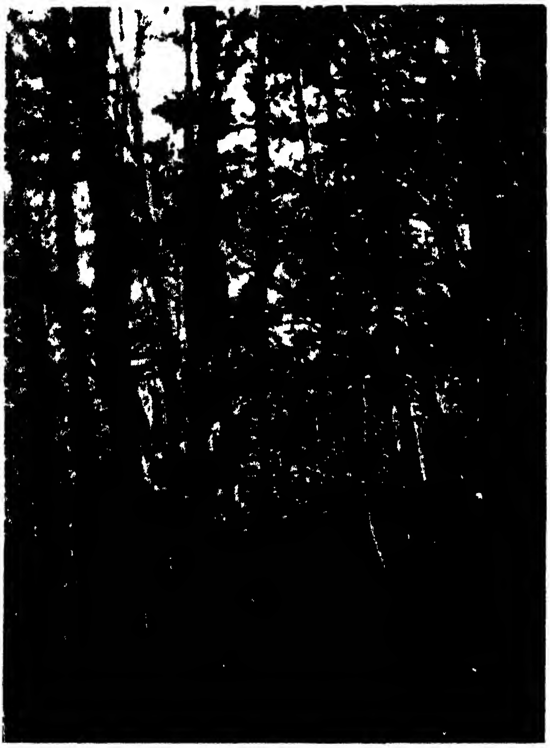


Fig. 7.—Rejuvenation of Silver Peaks forest where margin of forest had been broken.

Table A seeks to give an accurate survey of all the *Nothofagi* present* in this isolated colony, together with their diameters.

The light-intensity in the above colony was 1/55th of that outside the forest. Many of the southern-beech trees are clad to their tops with *Cyclophorus serpens*, and everywhere lichens reach high up into the upper branches; *Asplenium flaccidum* is a common epiphyte. The lichens† present were a species of *Ochrolechia*, several species of *Pannaria*, *Parmelia subphysodes*, *Parmelia* (species not identified), *Pseudocyphellaria Colensoi*, *P. chlorolerica*, *P. episticta*, *P. subvariabilis*, *Sphaerophorus melanocarpus*, *Sphaerophorus tener*, *Sphaerophorus* (sp.), *Sticta latifrons*, *S. sinuosa*, and a species of *Usnea*. Seedling plants a few centimetres in height are common growing on moss on fallen tree-trunks, and a few have germinated on the forest-floor, but seedlings with a height of 25cm. or more are practically non-existent. Saplings with small diameters are unhealthy, often decayed at their tops, and seem unable to continue for long the struggle for existence with the surrounding vegetation. A feature of this colony is the unusual lateral spread of some of the very old trees, which denotes a much more open association than is the case to-day.

In a few places light has been let in by fallen trees, and along a fence-line the undergrowth has been opened up, but the close ground-covering of *Blechnum discolor* (Fig. 3), and the fast-growing species of *Nothopanax* and *Coprosma* quickly discount the advantage given by the incoming light. The main factors prohibiting germination and rejuvenation of the *Nothofagus* in this locality seem to be, (*a*) lack of light caused by density of foliage of the parent trees and second-layer growth, (*b*) depth of raw undecomposed humus, (*c*) in places the close floor-covering of *Blechnum discolor*, *Nertera dichondraefolia*, and bryophytes.

(d) Flagstaff Creek. The few trees occurring here (altitude about 150m.) may be a remnant of a more extensive group destroyed in recent years; but the fact of their being close to a much-used road to North Taieri, and that no record has been made of their presence, would appear to leave little doubt that the group has not been extensive since the district was first settled. Only one large tree exists, now much decayed and broken. All stand on the edge of the creek, and are the only forest trees present. *Ulex europaeus* and *Cytisus scoparius* hem in the stream, while *Griselinia littoralis*, *Leptospermum ericoides*, *L. scoparium*, *Melicytus lanceolatus*, *Pseudopanax crassifolium* var. *unifoliolatum*, and other small trees also occur. During the last few years afforestation has been carried out by the Dunedin City Reserves Department and is rapidly covering up the grassland. The smaller southern-beech trees probably originated as seedlings from the large specimen, the seeds being carried the short distance from the parent plant by flood-waters, or even by wind.

---

*All seedlings 30cm. or more in height are included in the list, but the diameters of the smaller plants give no indication of their age, as will be shown in *Table C*.

†For the identification of these we are indebted to Dr. G. Einer Du Rietz, of Upsala, who accompanied us on a visit to this forest. He also kindly identified specimens from Silver Peaks forest.

(e) Boulder Hill. This group, about half a hectare in extent, and at an altitude of about 210 metres, is confined to the shaded side of a ravine on the south side of Boulder Hill. An almost continuous belt of *Leptospermum scoparium* of great density forms the outside margin of the forest and encloses an association of the following plants:—*Aristotelia serrata, Carpodetus serratus, Coprosma linariifolia, Fuchsia excorticata, Griselinia littoralis, Leptospermum ericoides, Nothopanax Colensoi, N. simplex, Pseudopanax crassifolium* var. *unifoliolatum,* and *Suttonia australis.* The interior of the stand is fairly open, and most of the above-mentioned plants enter into it, while *Blechnum discolor* and *B. procerum* occur sparsely on the forest-floor. *Polypodium diversifolium* and *Asplenium flaccidum* are present on the tree-trunks, but species of *Hymenophyllum* are absent, the habitat being comparatively dry. *Libocedrus Bidwillii* is represented by one tree only (20cm. diam.) growing in the midst of the southern-beeches. The larger trees of the group form a rough circle enclosing those of smaller diameters, and no seedlings or saplings occur on the outer margin of the area. Table B gives the number of *Nothofagi** present, together with their respective diameters.

TABLE B.

Number of *N Menziesii* Present.	With Mean Diameters Ranging From	Approx. Percentage of Total Number of *Nothofagi* present
13	0.5cm.— 2.5cm.	9.5%
34	Above 2.5cm.— 5 cm.	24.8%
23	„ 5 cm.— 7.5cm.	16 8%
9	„ 7.5cm.—10 cm.	6.6%
24	„ 10 cm.—15 cm.	17.5%
16	„ 15 cm.—23 cm.	11.7%
10	„ 23 cm.—30 cm.	7.3%
6	„ 30 cm.—45 cm.	4.4%
1	„ 45 cm.—60 cm.	0.7%
1	„ 122 cm.—137 cm.	0.7%

Total: 137 in the group.

The light-intensity in the above group was 1/25th of that outside the forest.

(f) Traquair Burn. This stand of *Nothofagus* (altitude 60m.) follows the creek for a short distance, and is composed entirely of small trees. On both sides the banks rise quickly, and in places precipitately, to hillsides covered with *Leptospermum scoparium* and in the larger growth of this the following are abundant:—*Aristotelia serrata, Clematis indivisa, Coprosma crassifolia, C. linariifolia, C. parviflora, C. rotundifolia, Coriaria arborea, Corokia Cotoneaster, Fuchsia excorticata, Griselinia littoralis, Helichrysum glomeratum, Melicytus ramiflorus, Pittosporum eugenioides, P. tenuifolium, Pseudopanax crassifolium* var. *unifoliolatum, Rubus australis* var. *glaber*, and *R. cissoides.* The stream rises quickly up beyond this through ground densely clad with small trees, and present as ground-plants are *Asplenium bulbiferum, A. flabellifolium, A. flaccidum,*

*All seedlings 30cm. or more in height are included in the list.

Blechnum discolor, Cyclophorus serpens, Pellaea rotundifolia, Polypodium diversifolium, and *Polystichum vestitum.* The soil is very free and dry, no tall trees of rain-forest are present, and as the whole area has been repeatedly burnt, particulars of its original covering cannot now be obtained. *Leycesteria formosa, Cytisus scoparius, Ulex europaeus,* and introduced grasses now occupy much of the burnt-over area.

(g) Taieri Mouth. An examination of the remnant of forest now reserved at this seaside resort indicates the type of vegetation that spread into all the gullies and over much of the hillsides along the coast in the locality. *Dacrydium cupressinum* is dominant, while *Podocarpus ferrugineus, P. spicatus,* and *P. totara* are abundant, and seedlings of all these are plentiful. *Leptospermum scoparium* covers some of the drier ridges and *Fuchsia excorticata, Griselinia littoralis, Leptospermum ericoides, Melicytus ramiflorus, Nothopanax Colensoi, N. Edgerleyi, N. simplex, Pittosporum eugenioides, P. tenuifolium, Pseudopanax crassifolium* var. *unifoliolatum, Suttonia australis,* and *Wintera colorata* are the smaller trees present. Some parts of the forest near stream-beds are extremely shady and ferns grow profusely. Generally the association is open and easily traversed, but species of *Coprosma* along with *Leptospermum scoparium* form tangled masses on the ridges. The road to Waihola from Taieri Mouth runs along a ridge, and on this road about one kilometre from the Mouth, and at an altitude of about 60m., *Nothofagus* trees were, many years ago, felled and drawn down the ridge to a saw-mill near the beach. Young trees not suitable for milling were left and many seedlings came up. Since that time, the second-layer trees and srubs with *Rubus australis* var. *glaber* and *Muehlenbeckia australis* have grown over the cleared area and, as the reserve at this point is not well protected, cattle-tracks are plentiful throughout. *N. Menziesii* was found by us at this point, and the forest on both sides of the ridge is an association of *Dacrydium cupressinum, Podocarpus ferrugineus,* and *P. spicatus, Nothofagus* evidently occupying the ridge only. At several places further south other scattered trees were located.

(h) Source of the south branch of the Waikouaiti River. This locality for *Nothofagus* was located only, and time as yet has not allowed a proper examination to be made of either the forest or of the occurrence of seedlings. Without doubt further groups still occur in this heavily-wooded area and in the vicinity of Mount Misery, one group being located at Horseshoe Bend, Waikouaiti River.

(i) Silver Peaks. This interesting stand (Fig. 4), over one square kilometre in extent, situated at the source of the south branch of Christmas Creek, is unbroken. It consists of pure *Nothofagus Menziesii* forest and is completely isolated from the usual rain-forest. The position is exposed to the full blast of southerly winds, and is within the area covered by driving mist during cloudy or wintry weather. Lichens make an almost complete covering of trunks and branches, a species of *Usnea* being the most noticeable; indeed the general appearance of the forest could best be compared with that of *Nothofagus* growing on shaded hill-slopes in the Fiord Botanical District. Amongst other lichens present are species of

Parmelia, Pseudocyphellaria Billardieri, Sphaerophorus melanocarpus, and *S. tener.* Trees of all sizes are present, some of them very large, the lower portions of their trunks being draped with *Polypodium diversifolium. Asplenium flaccidum* is a common epiphyte. The trees of the undergrowth are principally *Coprosma pseudocuneata, C. rhamnoides,* and *Nothopanax simplex.* Some large trees of *Griselinia littoralis* and *Libocedrus Bidwillii* are present. In places there is a good deal of rejuvenation within the forest (Fig. 5). A peculiar feature of this stand is that the specimens of *Libocedrus* are widely spaced and drawn up by the height of the *Nothofagus* to beyond their usual stature, and the majority are dying out; no seedling plants of *Libocedrus* were seen. In the forest heavy lateral growth of *N. Menziesii* is not very evident, most of the trees running up to their full height with but little branching, and the crowns are sparse.

The upper margin of the *Nothofagus* association ascends to approximately 600m., and the scrub-vegetation above is chiefly *Cassinia Vauvilliersii, Coprosma parviflora, Danthonia flavescens, Dracophyllum longifolium, D. uniflorum, Nothopanax Colensoi, Olearia arborescens,* and *Phormium Colensoi* (Fig. 6).

On the west *Danthonia flavescens* meets the edge, and some higher exposed ridges run down in tongues, in part dividing the forest. On the east the ground is more shaded and moist, *Blechnum procerum, Cassinia Vauvilliersii, Coriaria lurida,* and *Nothopanax Colensoi* being the dominant plants.

The mountain carries sheep, and burning is evident, in many places extending to the forest; seedlings and sapling trees are plentiful wherever the margin is broken (Fig. 7). The forest-floor is much broken up by wild pigs, and the fern-covering is usually *Polystichum vestitum,* though *Blechnum discolor* occupies occasional openings.

The greatest opponent to the forest growth is the fungus *Cyttaria Gunnii* which grows in grape-like colonies completely surrounding the stems of the saplings and on the branches of more developed trees causing large galls to form, many of them 30cm. or more in diam. In young trees the growth is altogether retarded, and everywhere throughout this forest branches are seen terminating abruptly at the gall, the upper part withering and falling away. In other cases the branch survives and is repeatedly attacked, galls often appearing at intervals along the branch.

4. Effect of Light.

A comparison of the differing rates of growth of *Nothofagus* under differing light-conditions is important. The specimens, measurements of which are given in Table C, were taken at random from the interior of the *Nothofagus* communities in the localities mentioned, and the annual rings were counted along a smooth bevelled section. The light-intensity in each locality was obtained by taking an average of six readings with a Wynne's exposure meter and comparing that average with an average of the light outside the forest.

TABLE C.

Bethune Gully. Light Intensity 1/55th.

Age.	Height	Diam	Average Increase in Diam. Per Year.
Years.	Metres.	Centimetres.	Centimetres.
22	2.43	1.5	0.0682
52	2.59	2.9	0.0558
70	6.09	3.8	0.0543
55	6.09	4.2	0.0764
71	5.48	4.8	0.0676
75	4.87	5.1	0.0680
85	5.18	6.4	0.0753
101	6.09	7.0	0.0693

Average increase in diameters per year = 0.0668 centimetres.

Boulder Hill. Light Intensity 1/25th.

Age	Height	Diam	Average Increase in Diam. Per Year
Years.	Metres.	Centimetres.	Centimetres.
26	2.43	1.6	0.0615
31	2.59	2.5	0.0806
57	3.65	2.7	0.0474
44	4.87	3.4	0.0773
55	4.57	3.8	0.0691
50	5.48	3.8	0.0760
82	6.09	6.4	0.0780
89	6.40	7.3	0.0820

Average increase in diameters per year = 0.0715 centimetres.

Silver Peaks. Light Intensity 1/13th.

Age	Height.		Average Increase in Diam. Per Year.
Years.	Metres.	Centimetres.	Centimetres.
24	2.43	1.8	0.0750
26	4.57	2.5	0.0961
39	4.87	3.7	0.0948
50	5.48	3.7	0.0740
46	6.09	3.8	0.0826
50	5.79	4.8	0.0960
69	5.18	6.7	0.0971
51	6.70	7.3	0.1431

Average increase in diameters per year = 0.0948 centimetres.

The above figures clearly show the effect of the light-intensity on the growth of the saplings. The Bethune Gully habitat with a light-intensity of 1/55th produced saplings showing an average increase in diameters of only 0.0668 centimetres per year. The Boulder Hill habitat with a light-intensity of 1/25th produced saplings showing an average increase in diameters of 0.0715 centimetres per year, while the comparatively open forest at Silver Peaks

with a light-intensity of 1/13th produced saplings with a more rapid rate of growth still (0.0948cm.).

Table D will serve to illustrate the rate of development under more open conditions. The specimens tabulated were taken from the remnant left at Mount Cargill (No. 3 habitat), and their mean diameters across the first 15 annual rings were taken, also the mean diameters of trees when felled. It is evident that during the first 15 years they were living under more adverse light-conditions than those experienced during the latter half of their existence.

TABLE D.

Specimens taken from Mount Cargill (No. 3 habitat).

Specimen.	Mean Diam. at 15 years	Mean Diam. and age when felled.	Average Increase in Diam Per Year.
No. 1	1.9 cm.	17.8 cm. at 30 yrs.	0.5933 cm.
No. 2	2.5 cm.	14.6 cm. at 32 yrs.	0.4562 cm.
No. 3	3.8 cm.	12.1 cm. at 30 yrs.	0.4033 cm.
No. 4	3.8 cm.	15.2 cm. at 31 yrs.	0.4903 cm.
No. 5	3.8 cm.	17.1 cm. at 30 yrs.	0.5700 cm.
No. 6	5.0 cm.	14.0 cm. at 32 yrs.	0.4375 cm.

Average increase in diameters per year = 0.4917 centimetres.

The intensity of the light must also, amongst other factors, influence the germination of seedlings. The Bethune Gully and Boulder Hill communities were particularly studied in this regard as they afforded an excellent opportunity for statistical analysis, both being totally surrounded by other forest, practically untouched by man or stock, and of a size that could be accurately surveyed.

A study of the figures concerning these groups—Tables A and B—will show that in the Bethune Gully group with a light-intensity of 1/55th of that outside, seedlings and saplings with diameters ranging from 0.5cm. —2.5cm. were present only to the extent of 2½% of the total plants, while in the Boulder Hill stand, with a light intensity of 1/25th of that outside, the proportion present was about 10%. It is also interesting to note that in the Silver Peaks forest, where the light intensity is 1/13th of that outside, seedlings and saplings occur freely. In this connection it must be borne in mind that the diameters and heights of many of the saplings are quite disproportionate to their age (see Table C).

5. Differences Between Nothofagus Forest and Subtropical Rain-forest.

In order to arrive at some logical conclusion on the occurrence of *Nothofagus* in all these widely-separated localities, the differences must first of all be noted between these southern-beech groups and the subtropical rain-forest which surrounds them.

The *Nothofagus* communities are usually composed of tall trees with sparse crowns, and they are generally open enough to make

progress through them a comparatively easy matter. This is in marked contrast to conditions prevailing in rain-forest, progress through which is often well-nigh impossible unless the slasher or axe is brought into play.

In southern-beech forest tree-ferns are frequently absent or few in number, and species of *Coprosma* and *Nothopanax* are as a rule the greatest bar to progress. The forest-floor covered with closely-matted undecomposed leaves carries comparatively few ferns as compared with the wealth of the latter in rain-forest; the ground is usually drier and filmy ferns and the larger lichens are not a feature. *Rubus* and *Muehlenbeckia* are absent and, while *Asplenium flaccidum* and *Polypodium diversifolium* are common, other vascular epiphytes are not strongly developed. *Cyclophorus serpens,* a plant of dry situations, is here the one exception. Mosses and liverworts occur but do not make the close green mantle common to associations of rain-forest. In almost every case these isolated groups of *Nothofagus* are confined to ridges or convex slopes holding but little moisture, and the surrounding rain-forest occupies the moister and more level situations.

The most striking difference between the two types of forest, however, is the conditions offered for the germination and development of seedlings within the precincts of the forests themselves. If these local *Nothofagus* communities are not actually hostile to the seedlings of *N. Menziesii,* they certainly do not encourage them within their borders. The rain-forest treats its progeny in an altogether different manner, better conditions for the germination and future welfare of the young plants being afforded. Regeneration in the southern-beech forest depends on the death of the older trees; light is admitted allowing the young trees to develop. An instance of this may be recorded from a sapling growing in the Boulder Hill group. It had 18 annual rings in the first 2cm. of its diameter and then grew only 12 additional rings to reach 18cm. diam. Evidently a fallen tree had let in the light and the plant had rushed ahead.

Seedlings in abundance are found only in the outer edge of pure southern-beech forest, as for instance at Silver Peaks where there is no enveloping rain-forest, or in places where fallen trees or cleared spaces let in the necessary light. We have found that *Nothofagus* seeds invariably germinate, and seedlings are established and flourish best under the following conditions: (a) Along the edges of burnt or cleared forest; (b) where the soil has been disturbed by flooding or land-slips; (c) where the ground-covering of undecayed humus has been disturbed by temporary grazing or other means, e.g., rooting of wild pigs. This disturbance enables the young plants to take root, where in heavy humus ground seeds would perhaps germinate but would not obtain roothold and develop.

The vitality of *Nothofagus* and its capacity for flourishing in extremely diverse situations must not be overlooked. Trees growing near streams, on stream-banks and in positions exposed to frequent flooding, are as well-developed and healthy as are those on the ridges, and are quite able to carry—as at Woodside and Maungatua—huge masses of *Elytranthe Colensoi* without seemingly being greatly affected.

6. Examination of Cockayne's Theory in the Light of the Occurrence of Nothofagus in the Dunedin Area.

As nothing in nature can stand still and all forest is in a continual state of change, *Nothofagus* must either be a new-comer throwing out its seedlings into the surrounding or adjacent rain-forest and spreading on all sides, or else it is a remnant of primeval forest making its last stand against an invader. From our observations we are convinced that there is no middle course, that the two types of forest do not live amicably together and pursue a common destiny. There is no real union, and as Cockayne states (1926: 27): "There is properly not one but two distinct plant-formations side by side." A study of all these isolated *Nothofagus* groups in the Dunedin area convinces us of the truth of Cockayne's statement, and creates a lasting impression that these groups are slowly but surely being choked out by the pressure of the antagonistic rain-forest. That species once common can be wiped out, is shown by the fate of *Podocarpus spicatus* in Stewart Isltnd where *Weinmannia racemosa* has almost replaced it (Cockayne, L., 1921: 124). It is natural to expect an invader of an island to take possession first of the shores, then to encompass the lower country and finally to push up into the high lands as far as conditions will allow. One would not expect and certainly we can supply no evidence of an invasion of *Nothofagus* from the higher country down into the lower.

These local groups, stands, or colonies of *N. Menziesii* are usually surrounded by rain-forest but never surround such forest, nor does the *Nothofagus* ever appear on the margin of the rain-forest, pushing its way in as would be the normal course of attack. In the Dunedin area *Nothofagus* seedlings or saplings do not occur outside of their own colonies, and do not develop without the incoming of light, and this the encroaching undergrowth of the rain-forest absolutely prohibits.

In certain stages of the conflict it is possible for isolated *Nothofagus* trees to be left, dotted here and there, in the midst of the subtropical forest, thus giving the impression that a mixed *Nothofagus*-subtropical forest-association is being viewed, but though individual *N. Menziesii* trees do occur in this manner, this stage is very little in evidence in the Dunedin area. These isolated trees will of course persist for hundreds of years in such situations, but even if their seeds germinate, the seedlings are suppressed and expansion becomes impossible. When we consider the unthinkable amount of time that the fight has been going on, the comparative slowness of decisive results, and the wide areas—North Auckland to Foveaux Strait—over which the struggle is being waged, it is little wonder that here and there places occur in which the result of the battle may not appear to be in favour of the legions of the subtropical rain-forest.

Moreover, taking into consideration the vast areas already occupied by *Nothofagus* in New Zealand, if it be a new-comer it certainly should be a very aggressive one. That this is not so may easily be seen by studying any of the local groups cited in this paper. For instance, at Bethune Gully, southern-beech trees of great age are present in numbers, trees moreover which to all appearances are

older than the oldest trees of the surrounding rain-forest, and although these have had time for their progeny to settle down over large tracts of country, the change is retrogressive, not progressive! The extreme age of these old trees makes the observer wonder why they have not, so to speak, populated the earth, especially when the capacity of the seedlings for rapid and forward growth is taken into account, a rate of growth much in excess of that of any of the species of New Zealand rain-forest.

That if man does not interfere the larger-leaved forest trees will ultimately push back and replace the *Nothofagus* is, however, certain. The dense entangled undergrowth of second-layer trees, the shading canopy of shrubs and tree-ferns, and the close floor-covering of *Blechnum* and *Polystichum,* will in the end inevitably conquer in the struggle of the subantarctic primeval vegetation against the subtropical invader!

SUMMARY AND CONCLUSIONS.

1. The paper deals with the relation, in the country adjacent to Dunedin (South Otago Botanical District), of the subtropical forest to the subantarctic forest—the former a forest dominated by broad-leaved dicotylous trees and podocarps, and the latter (taking the formation for all New Zealand) by one or more species of *Nothofagus.*

2. Most of the forest near Dunedin is subtropical, but there are also at least twelve pieces of *Nothofagus Menziesii* forest, mostly quite small, and the question to be answered at once arises, "Is *N. Menziesii* a new arrival or merely a survivor of a former host?"

3. This question leads up to a verification or negation of L. Cockayne's theory that *Nothofagus* forest was originally the chief tree-community of New Zealand, but that it has been gradually replaced on the more fertile ground by a subtropical forest of Malayan origin, so that now it is restricted to the poorer ground and to the higher altitudes.

4. Prior to this study, only 5 pieces of *Nothofagus* forest had been recorded near Dunedin (of these, 3 remain), but the authors record 9 more, one of which is no less than a square kilometre in area.

5. Each of the *Nothofagus* communities is described in detail, and lists of the species are given.

6. One area—Bethune Gully—is an unbroken colony of *N. Menziesii* standing in the midst of a heavy association of subtropical forest, all its *Nothofagi* (168) were measured and a table is presented placing them into 16 classes according to their average diameters, and the percentage of trees for each class is given.

7. A similar table is presented for 137 *Nothofagi* in another of the areas.

8. Three other tables are presented which show the relative rates of growth of 8 trees in 3 areas, the light-intensity of each area as compared with that of the open being respectively 1/55, 1/25, and 1/13, the average annual increase in diameter for the young trees in each area being respectively 0.0668cm., 0.0715cm., and 0.0948cm.

9. A fourth table shows the rate of growth of 6 trees under still stronger light, the average annual increase in diameter being 0.4917cm.

10. A main difference in structure between subtropical forest and *Nothofagus* forest is the extreme density of the former and the openness of the later.

11. The interior of the *Nothofagus* communities is not favourable for the establishment of seedling *Nothofagi,* the most favourable positions being (a) along the edges of burnt or cleared forest, (b) where the surface-soil has been disturbed by grazing or rooting animals, and (c) where the soil has been disturbed by flooding or land slips.

12. The conclusions regarding the matters outlined in 2 and 3 are as folows:—

(*a*) Either *Nothofagus* is a new-comer or the forest it dominates is a remnant of an earlier primeval forest.

(*b*) The study of the isolated *Nothofagus* groups in the Dunedin area supports Cockayne's theory, for such groups are slowly but surely being suppressed by the antagonistic subtropical forest.

(*c*) There is no evidence of an invasion of *Nothofagus* from the higher levels to the lower.

(*d*) The local groups of *Nothofagus* forest are usually surrounded by subtropical forest and they never surround the latter, nor does *Nothofagus* ever appear on the margin of subtropical forest, pushing its way into that community.

(*e*) *Nothofagus* seedlings or saplings do not occur outside of their own class of forest nor can seedlings become established beneath the dense undergrowth of subtropical forest.

(*f*) Were *Nothofagus* a new-comer it should be very aggresive whereas, in the Dunedin area, quite the contrary is the case.

PAPERS ETC., REFERRED TO.

Cockayne, L., 1921. *The Vegetation of New Zealand*, pp. 124, 322-23.

Cockayne, L., 1926. *Monograph on the New Zealand Beech Forests*, Part 1, pp. 27, 30, 39.

Dunedin Field Club, 1916. *Catalogues of the Indigenous and Introduced Flowering Plants, Ferns, and Seaweeds, occurring in the Dunedin District*, p. 21, Dunedin, Orr, Campbell and Co.

Petrie, D., 1896. List of the Flowering Plants indigenous to Otago, with indications of their Distribution and Range in Altitude, *Trans. N.Z. Inst.*, vol. 28, p. 573.

Watt, M. N., 1924. Leaf mining insects of New Zealand, *Trans. N.Z. Inst.*, vol. 24, pp. 674-675.

The Structure and Development of *Astelia nervosa* var *sylvestris.*

By Elma M. McCarthy, M.Sc.
(Communicated by Dr. J. E. Holloway.)

[Read before the Otago Institute 8th May, 1928; received by Editor, 12th May, 1928; issued separately, 30th August, 1928.]

Plate 52.

The following account of certain aspects of the structure and development of *Astelia nervosa* var. *sylvestris* is taken from a thesis written at the Botany Laboratory, University of Otago, under the direction of Mrs. M. W. Aitken, M.Sc. It owes its present form to the help and encouragement extended by Dr. J. E. Holloway.

Astelia nervosa var. *sylvestris* is a stout perennial herb growing abundantly under mesophytic conditions on low hillsides in both islands. The leaves are arranged in dense tufts, a number of which combine to form the large head which comprises the plant. The growth-form of the Asteliads is very similar but *Astelia nervosa* can be distinguished from other species by its orange berry, the perianth of which is enlarged and coloured. The leaf is long and narrow, varying in length from 3 — 5 ft. and in breadth from 2 — 3 inches. It is many nerved but three nerves are very conspicuous, and are coloured red with anthocyanin, which is dissolved in the cell-sap of the superficial cells. The leaf as a whole is flexible, but the base is white and succulent and clothed by a tomentum of long silky hairs.

Astelia nervosa var. *sylvestris* is very similar to *Astelia Cockaynei* (*Astelia nervosa* var. *montana*). The latter is found mostly in subalpine situations as a small sturdy plant covered with hairs. The structure of the leaf of *Astelia Cockaynei* as found in the Peridotite Belt, Nelson, is described in "Notes on the Autecology of Certain Plants of the Peridotite Belt, Nelson" (*Trans. N.Z. Inst.*, vol. 52, pp. 305-308) by Miss M. Winifred Betts, M.Sc. It is practically the same as that of *Astelia nervosa* var. *sylvestris*.

It also has some resemblance to *Astelia Solandri*, as described by Miss J. H. Wilson, M.Sc. in "Some Plants from the Lava-Field at Mt. Wellington" (*Trans. N.Z. Inst.*, vol. 58, pp. 259-263). This resemblance lies chiefly in the anatomy and function of the leaf bases (Wilson, p. 262).

The only other paper dealing with the anatomy of the Asteliads is one by Miss E. M. Herriott, M.A. (*Trans. N.Z. Inst.*, vol. 38, pp. 377-422), "On the Leaf Anatomy of *Astelia linearis* var. *sublata.*" This leaf has no close resemblance anatomically to that of *Astelia nervosa* var. *sylvestris.*

Microscopic Structure of Mature Leaf. (Figs. 1-6).

Over the midrib the upper epidermis is composed of small cells, beneath which is an aqueous tissue consisting of 4-6 layers of colour-

less palisade-shaped cells very regularly arranged. The chlorenchyma is below this, and is represented by about 10 layers of spongy parenchymatous cells. The lower epidermis consists of 2 rows of small colourless cells. The fibro-vascular bundle forming the midrib,

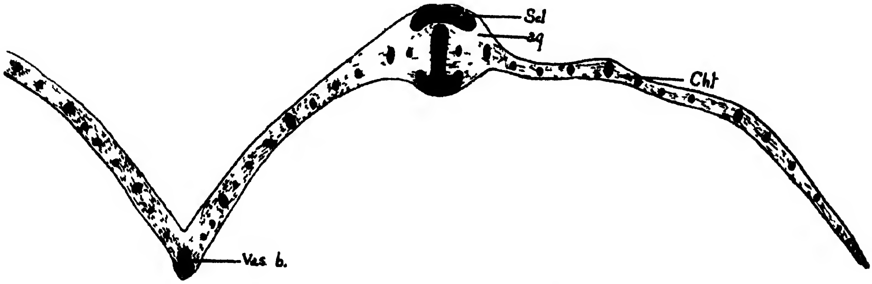


FIG. 1.—Diagramatic section of part of a leaf × 4

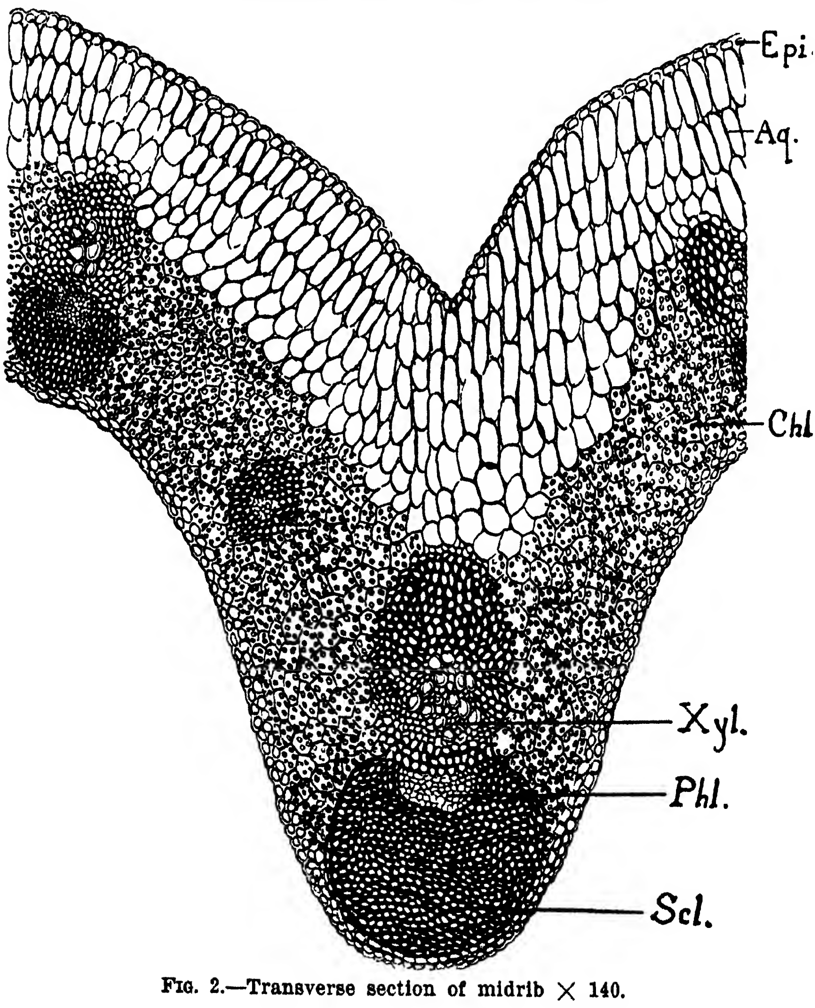


FIG. 2.—Transverse section of midrib × 140.

stretches from the aqueous tissue to the lower epidermis, where it forms a conspicuous ridge on the under-surface of the leaf. The upper flange of mechanical tissue is a crescent-shaped mass of sclerenchymatous cells. It is smaller than the lower flange which would be circular but for a small area occupied by the phloem.

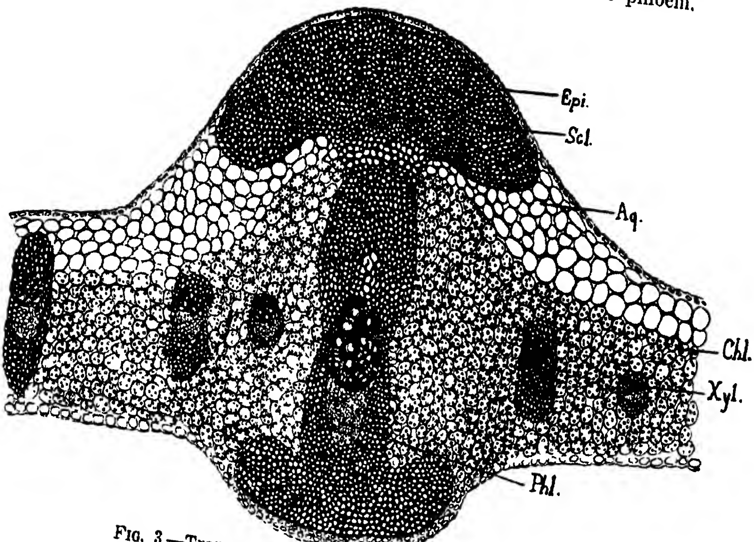


Fig. 3.—Transverse section of prominent side vein × 60.

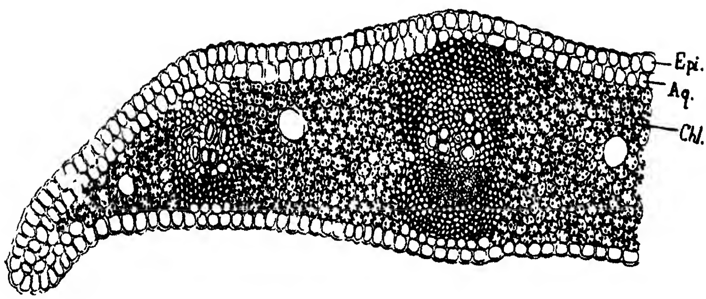


Fig. 4.—Transverse section of leaf at margin × 200.

The most prominent nerves of the leaf are the two lateral ones. This is due to a very conspicuous anchor-shaped girder of mechanical tissue stretching from one epidermis to the other. The upper flange is the larger and the vascular bundle occupies only the lower half of the web. The aqueous tissue is slightly wider near these veins, and the cells are almost spherical and loosely arranged. Two layers

extend to the web of the girder underneath the upper flange. Towards the midrib the chlorenchyma increases greatly in thickness the upper limits being almost parallel to the surface of the leaf

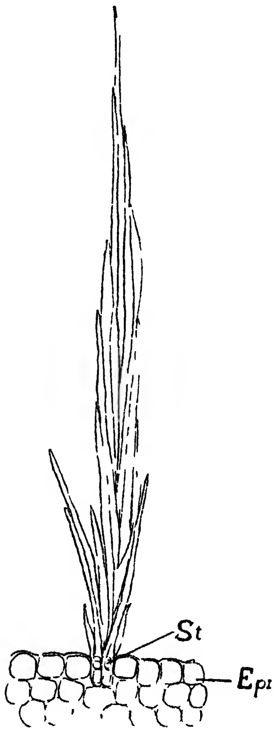


FIG. 5.—Multicellular hair from base of leaf × 125.

which here projects as a ridge. Towards the margin of the leaf the epidermal cells become larger and the aqueous cells smaller. The aqueous tissue is here only one layered, the chlorenchyma occupying most of the leaf. Between each bundle is a large colourless cell several times larger than an ordinary cell of the chlorenchyma. The fibro-vascular bundles are similar to all the other minor bundles of the leaf, that is, they have mechanical tissue in the form of two crescent-shaped areas, one above, one below the vascular bundle. A slight variation occurs in the end-bundle where the upper flange is practically undeveloped.

At the base the leaf is soft and white and covered with a tomentum of silky hairs. These occur on both surfaces of the leaf, but are more numerous on the inner or upper surface. The hairs arise below the level of the epidermis and consist, below the epidermis, of a short stalk 2 or 3 cells deep and 2 wide. Beyond the level of the epidermis the hair branches out in several directions, but as a whole continues at right angles to the surface, branches being given off to the right and left. The branches, which are unicellular, remain close to the parent axis. On some hairs a number of branches are

given off together forming a whorl. The mesophyll is composed of round loosely-arranged cells which near the upper epidermis form a sponge-like tissue with large intercellular spaces. The three main veins are not conspicuous, but above each large vein is a triangular mass of collenchyma. Below the veins are crescent-shaped gum-passages. The gum is apparently secreted by special mucilage vesicles which project into the gum-passages. These passages, unlike those of *A. Solandri* (Wilson p. 262), are found only in the leaf-base.

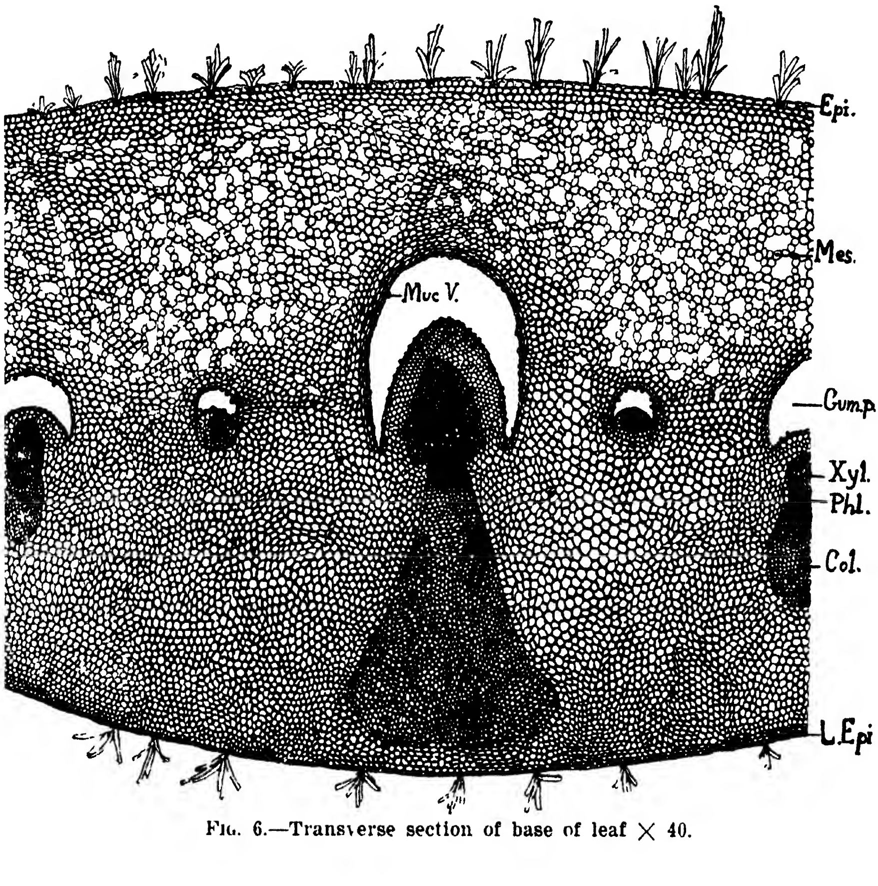


Fig. 6.—Transverse section of base of leaf × 40.

Microscopic Structure of Leaf of Seedling. (Fig. 7.)

The leaf of a 4-inch-high seedling is slightly thicker in the proximity of the main vascular bundles. On the upper surface there are 2 layers of colourless polygonal cells, the lower representing the aqueous tissue. The chlorenchyma which consists of from 3-6 layers of cells is in the form of spongy parenchyma. The lower epidermis consists of a single layer of cells except near the midrib where there are two layers. At this stage the leaf has 7 veins. These are the three main veins with a small group of sclerenchymatous cells above and below the vascular strand, two fairly large veins with no

mechanical tissue, and two small veins between the main laterals and the midrib. At the base of the leaf there are no .gum-passages. These appear together with the hairs when the plant is about 2 ft. high.

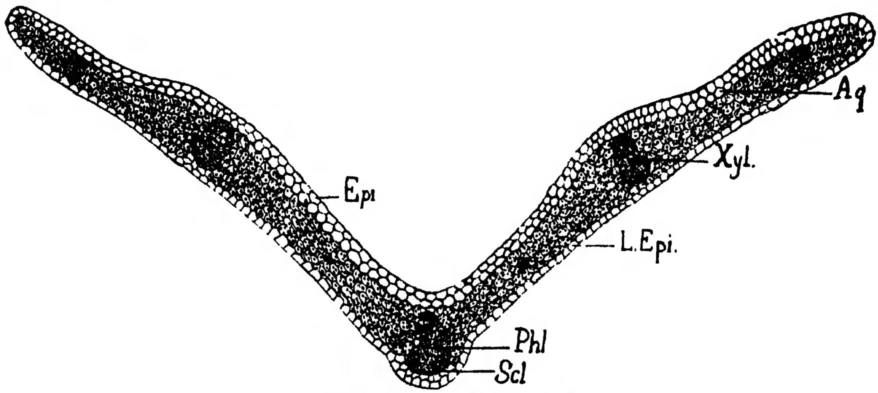


FIG. 7.—Transverse section of young leaf × 50.

MICROSCOPIC STRUCTURE OF PEDUNCLE OF INFLORESCENCE (Fig. 8).

The triangular peduncle has a ground-tissue of round cells rich in starch. The outer layers contain a few chloroplasts and are surrounded by a dermis of tabular-shaped cells. About 1/50 - 1/75

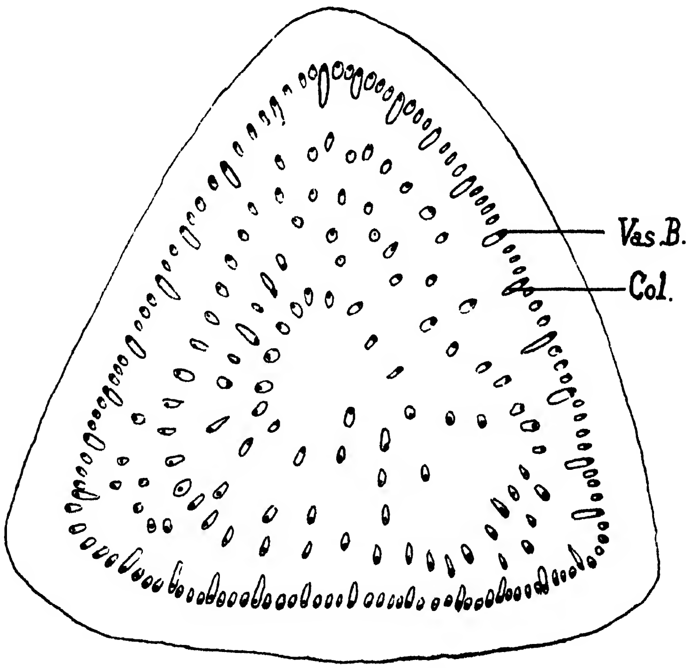


FIG. 8.—Diagramatic section of peduncle of flowering shoot × 12.

of an inch from the dermis and parallel to it lies a row of vascular strands. Along this row large vascular bundles occur at fairly regular intervals, the space between each being occupied by 2 or 3 smaller ones. Inside this row vascular bundles are scattered through the ground-tissue. The mechanical tissue, especially in plants grown in the shade, is not well developed.

Flowering (Figs. 9 and 10).

Cheeseman (p. 317) states that *Astelia nervosa* is a dioecious plant. All the specimens examined by the writer, however, seemed to be hermaphrodite. This was confirmed by microscopic examination. All the anthers contained pollen-grains and in most cases the ovaries contained ovules. In some cases however the ovules were not well developed and were possibly functionless. An examination of the plants in the fruiting season shows a luxuriant development of fruit on some plants, while others have none at all. This would certainly seem to indicate the dioecious habit. *Astelia nervosa* var. *sylvestris,* however, does not flower and fruit every year. Investigation over a number of years is necessary before the position can be stated definitely.

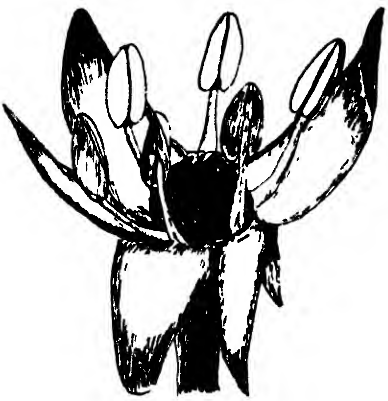


Fig. 9.

Fig. 10.

Fig. 9.—Individual flower × 6.
Fig. 10.—Small portion of flowering spike (nat. size).

About February and March individuals about to flower appear slightly swollen at the base. The inflorescence is formed at the apex of the shoot, a new shoot arising laterally to carry on the growth of the tuft. The flowering-scape appears above ground at the begining of September, and when only 4 or 5 inches long the pollen-grains and ovules are already formed. The buds open shortly after they emerge from the bracts and surrounding leaves, so that the tip of the spike is often in full bloom before the rest of the spike

has appeared. The flowers are not conspicuous, the colours being very dull, but they have a sweet scent. In contrast to the flower the fruit is very conspicuous, each spikelet being crowded with brilliant orange berries. The berries soon drop off when the succulent perianth, which at first is closely pressed to the berry, turns back. The number of seeds per berry varies from 3-10, 8 being the most frequent number. The seeds are smooth, black, and angular, with a bright polished appearance. The testa is very hard, thick, brittle, and practically impermeable to water.

Structure and Development of Anther (Figs. 11 and 12).

In a very young flower, when the whole inflorescence is about an inch long, the stamen is quite undifferentiated, being represented by a mass of homogeneous tissue, kidney-shaped in transverse

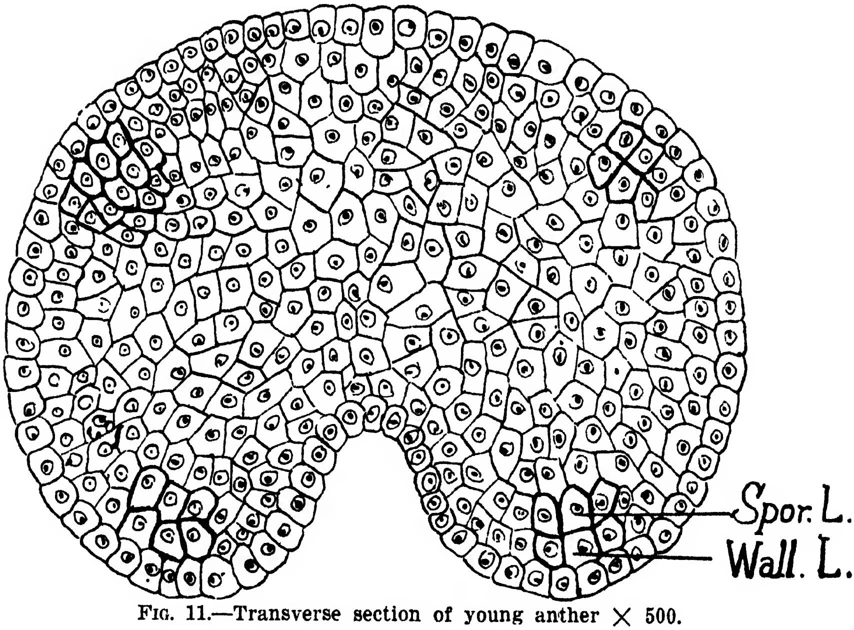


Fig. 11.—Transverse section of young anther × 500.

section. A longitudinal section at the same stage shows a cone-like structure with no distinction between anther and filament. A little later some of the cells of the hypodermal layer divide to form the primary wall-layer and the primary sporogenous layer. This cell-division takes place, as in most Angiosperms, in 4 regions of the anther. Transversely the anther is still the same shape, but in longitudinal section shows a slight constriction at the base. This is the beginning of the differentiation into anther and filament. The primary sporogenous layer divides until several layers of sporogenous cells are formed. Some of the wall-layers form a tapetum which is partially disorganised in the spore-mother-cell stage. In longitudinal section at this point the anther and the filament are quite distinct.

The filament, however, is very short while the anther is almost the mature size. The opening of the bud therefore entails a great elongation on the part of the filament. The stamens pass the winter in the spore-mother-cell stage.

At the beginning of spring the spore-mother cells divide to give the tetrad of pollen-grains which have sculptured coats. Directly below the epidermis of the anther is the endothecium which is composed of a layer of palisade-cells. Between the adjacent sporogenous tissues of an anther lobe are 2 or 3 layers of thin-walled cells. In dehiscence this thin-walled tissue breaks down with the result that there is now a single compartment in the anther-lobe. In the region

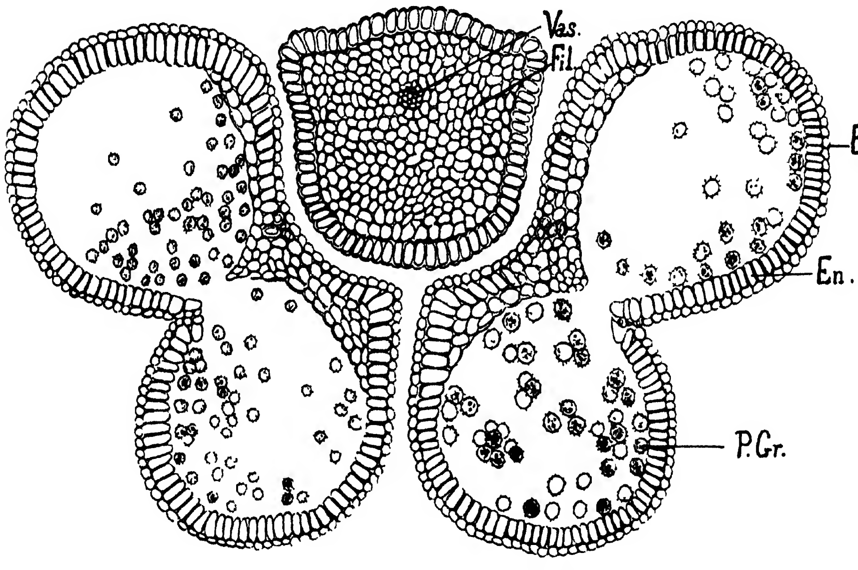


Fig. 12.—Transverse section of anther × 100, showing the coalescence of the 2 adjacent pollen-chambers.

of the thin-walled cells the epidermis and endothecium are bent inwards, the apex of the bend being occupied by the thin-walled tissue. Consequently when this breaks down, the wall is not continuous, and with a slight increase of pressure may be bent backwards setting the pollen-grains free.

Structure and Development of Ovule (Figs. 13-19).

The ovule originates in the ovary about the same time as the division to form the spore-mother-cells occurs in the anther. The nucellus appears first as a protuberance on the placenta. A transverse section at this stage shows the three carpellary leaves with the ovules as small outgrowths at their margins. As the ovule develops the nucellar mass protrudes further and gradually bends sideways and downwards. The first integument soon appears as a ring round the base of the nucellus. Later, but before the first integument envelops

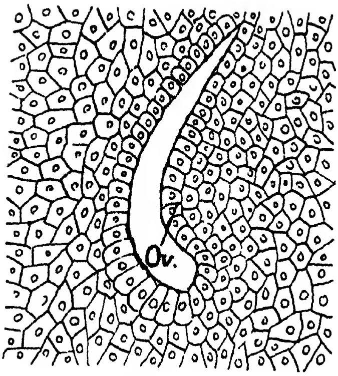


Fig. 13

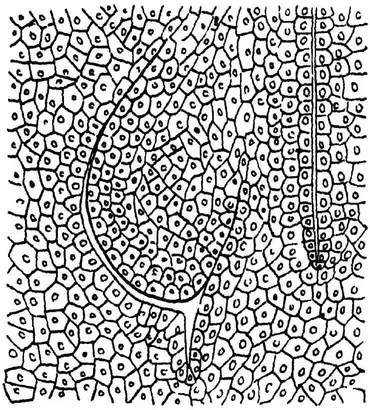


Fig. 14.

Fig. 13.—Longitudinal section through a very young ovary × 380 showing the ovule as a slight protrusion of nucellar material.

Fig. 14.—Longitudinal section through ovary × 380, showing young ovule bending sideways and downwards.

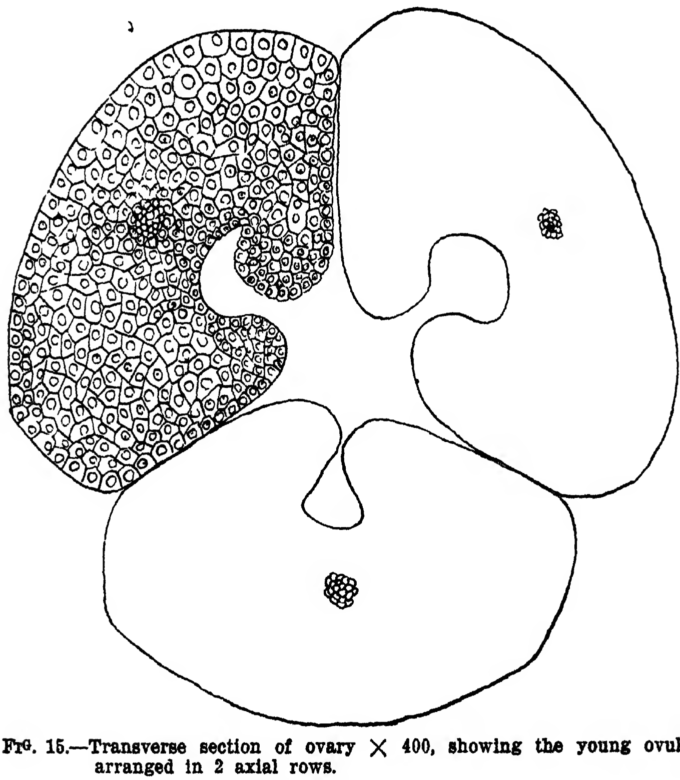
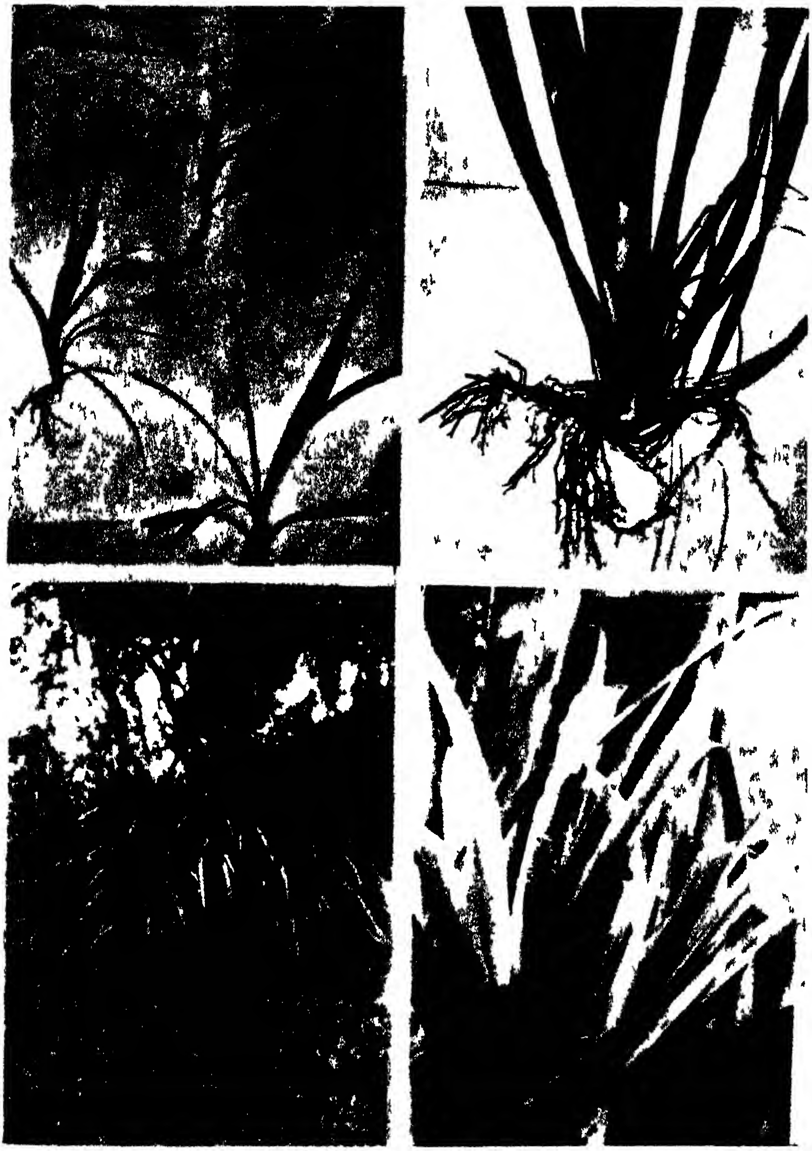


Fig. 15.—Transverse section of ovary × 400, showing the young ovules arranged in 2 axial rows.

A B

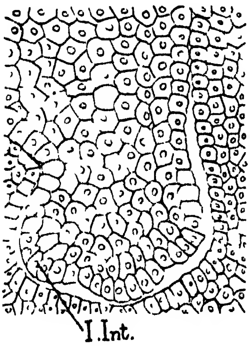


C D

A Stages in the development of the seedling
B Head of leaves of *A nervosa* showing the root system
C *A nervosa* in a fairly open habitat
D *A nervosa*, showing tip of flowering shoot in full bloom

the nucellus, the second makes its appearance on the outer side of the ovule. At the same time the embryo-sac can be distinguished in the third layer, below the apex of the nucellus, as a round cell slightly larger than the others. About the time that the first integument has grown beyond the nucellus, a cavity is formed below the

Fig. 16.



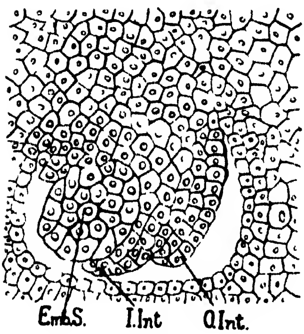


Fig. 17.

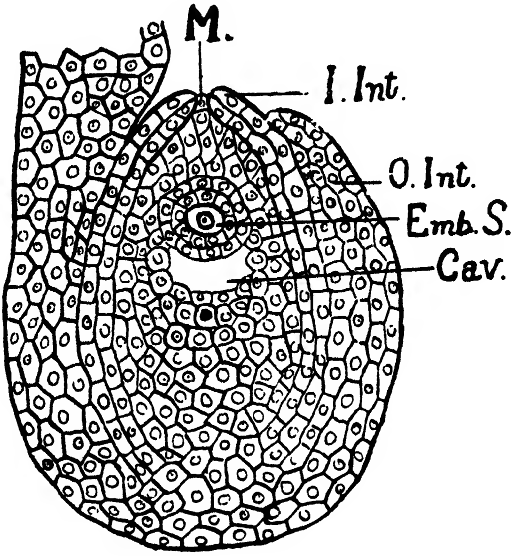


Fig. 18.

Fig. 16.—Longitudinal section through ovary × 260, showing ovule with the first integument appearing as a ring round the base of the nucellus.

Fig. 17.—Longitudinal section through ovary × 250, showing an ovule with the first and second integuments and the embryo-sac.

Fig. 18.—Longitudinal section of a young ovule × 300.

enlarging embryo-sac, probably by the breaking down of some of the cells of the nucellus.

The mature ovule is anatropous with an inner and outer integument. The former is 2 cells wide, while the latter varies from 3 cells at the micropylar end, to five at the chalazal. On the inner side of the ovule, the funiculus and the outer integument cannot be distinguished. The embryo-sac occupies only a smal portion of the ovule, lying immediately below the micropyle. The cavity below the embryo-sac has greatly increased in size by the breaking down of the nucellar tissue. At the base of the cavity is a peculiar star-shaped structure which consists of 3 or 4 small cells with thick walls, round which radiate elongated cells. Below this the nucellus is prolonged into the tissue of the chalaza as a tongue-like outgrowth

of small radially-extended cells. The walls of the loculi contain in their cells bundles of very long raphides, a type of crystal found in several other parts of the plant.

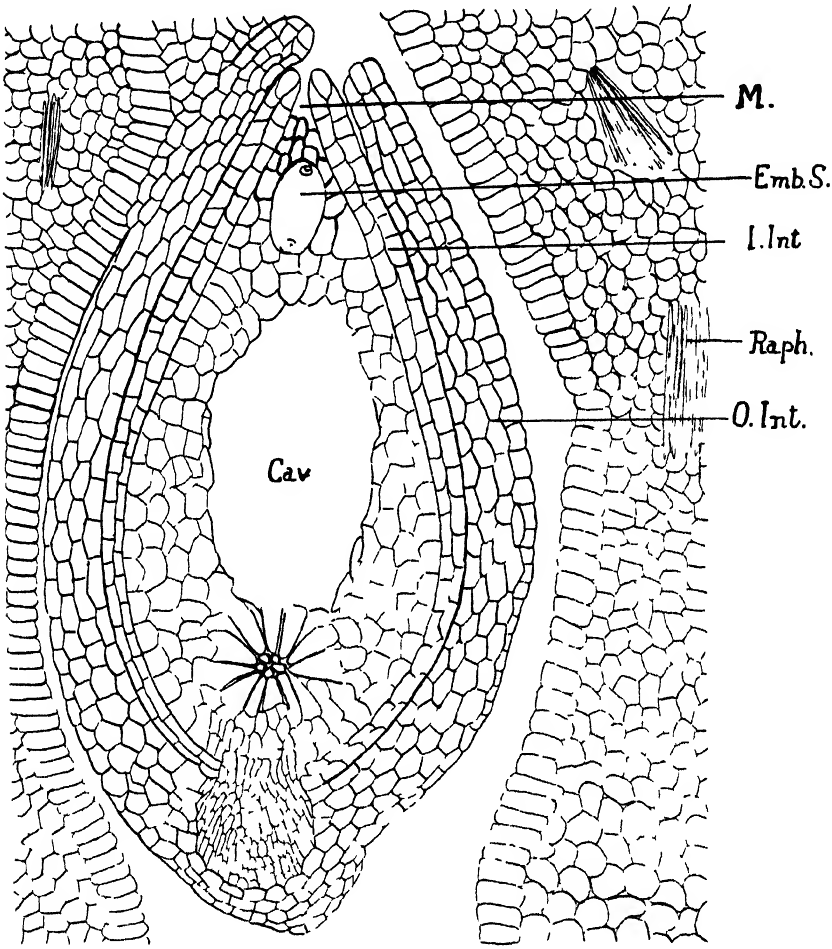


FIG. 19.—Longitudinal section of an ovule × 380.

STRUCTURE OF FRUIT AND SEED (Figs. 20, 21).

A berry, when still small and green, is seen in longitudinal section to have a dermis of rectangular cells inside which polygonal cells interrupted by an occasional vascular strand stretch to the cavity of the berry. The young seed has the cavity and star-shaped structure typical of the mature ovule. The testa, however, is now distinguishable and appears to be striated.

In the ripe seed the testa is hard and brittle. The embryo is situated at one end, with its long axis parallel to the long axis of the seed. It is of the usual mono-cotyledonous type, with a terminal

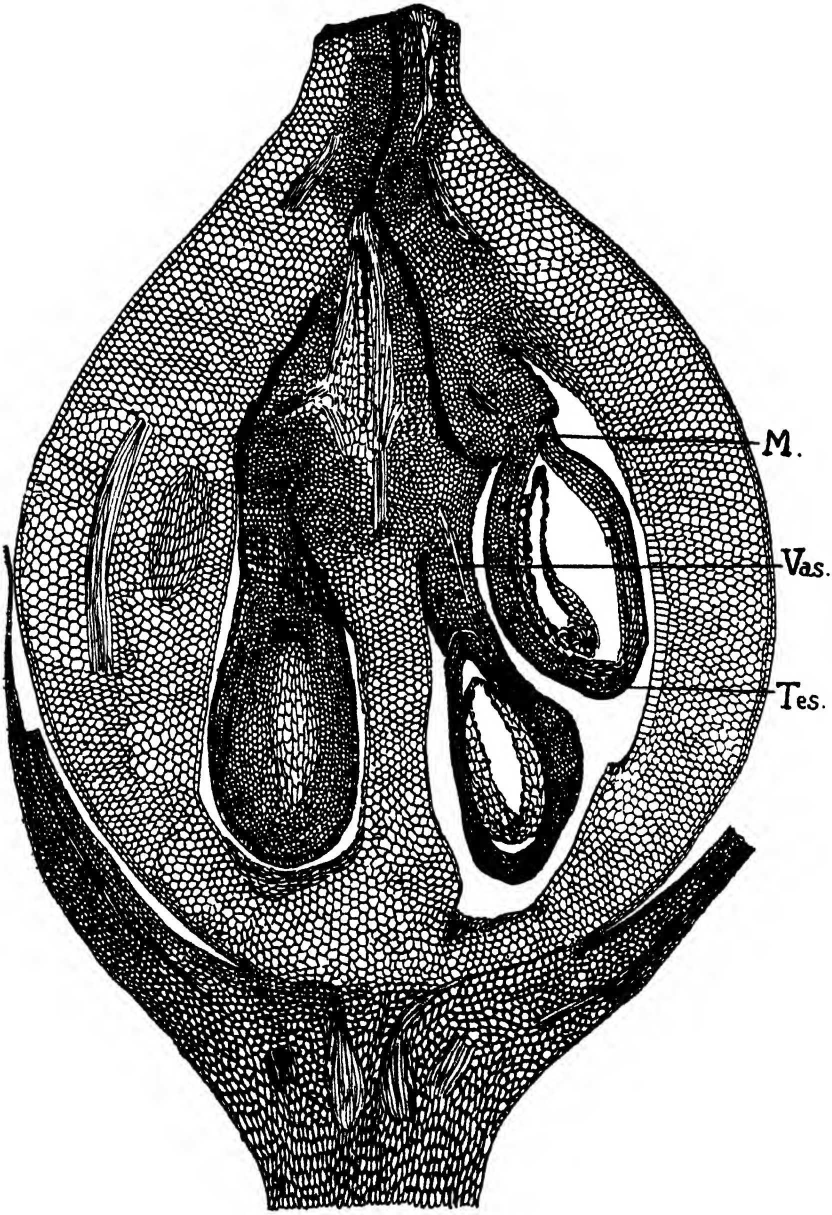


Fig. 20.—Longitudinal section of young berry × 60.

cotyledon and a lateral growing point. Round the embryo radiate in regular rows the endosperm cells.

GERMINATION (Figs. 22-24).

The seed may not germinate for some time, but eventually the first root and the first foliage-leaf make their appearance. The

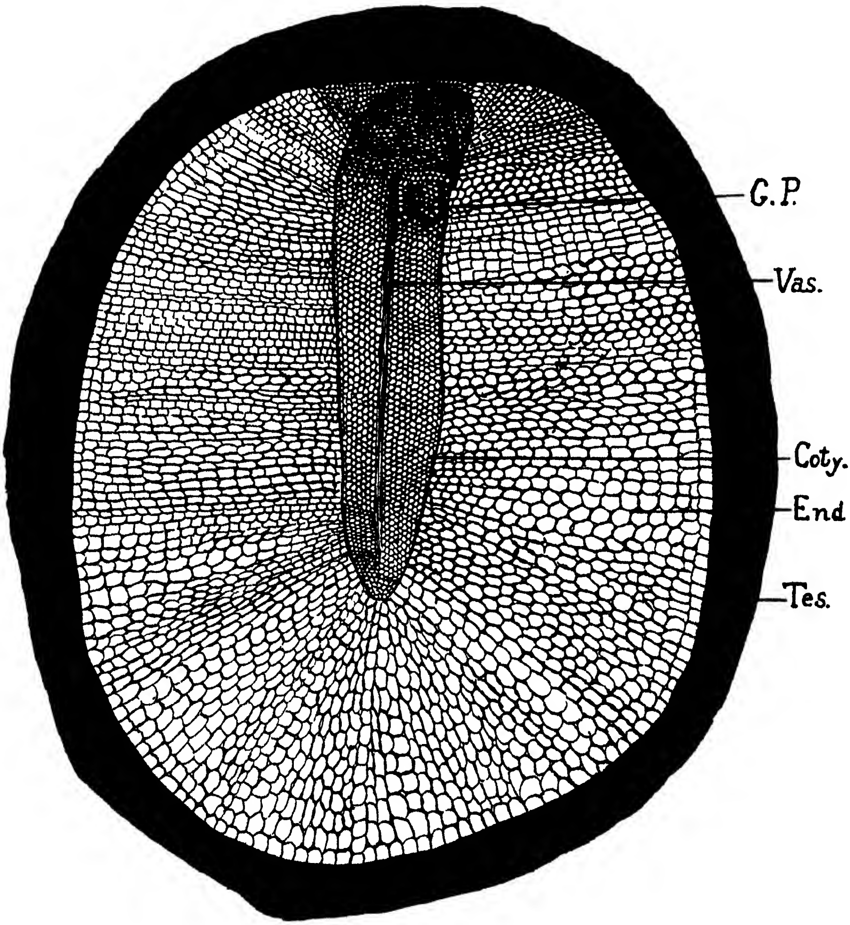


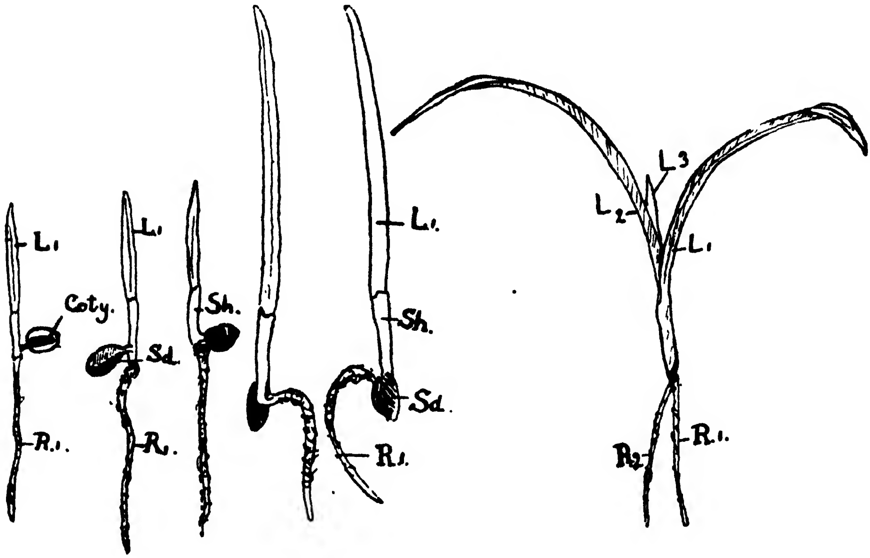
FIG. 21.—Longitudinal section of seed × 295.

cotyledon remains inside the testa and acts as an absorbing organ of the young plant. The endosperm is gradually disorganised, a milky-looking fluid being formed.

The first leaf is enclosed in a sheath, through which it breaks its way, and shows above ground as an acicular blade. Later the second leaf appears enclosed by the base of the first, then the third enclosed by the base of the second, and so on. As the leaves

develop new roots make their appearance at the point of origin of the primary root.

As the seedling grows its hypocotyl becomes more complex. Near the root its shape is circular, in cross section, in contrast to the triangular form found further up the hypocotyl. The limits of the leaves can be distinguished by a layer or layers of cells less crowded



1 2 3 1 2
A B C

Fig. 22.—A. Seedling with seed still attached × 2.
(1. With seed split open. 2 and 3. Front and back views respectively.)
B. Slightly older seedling × 2.
C. Still older seedling (nat. size).

with starch-grains than the bulk of the hypocotyl. The leaves themselves are ring-shaped in transverse section and the structure of the two outermost can be clearly seen. They have an upper and lower epidermis of large cells containing no starch-grains. The vascular bundles are present but there is no mechanical tissue in connection with them. The rest of the leaf is occupied by spongy parenchyma crowded with starch-grains.

Further up the hypocotyl the leaves, in transverse section, are shaped like a hollow triangle, the third side being composed of 2 layers of colourless epidermal cells. The outer leaves as in the lower hypocotyl, are crowded with starch-grains, but inside these are seen

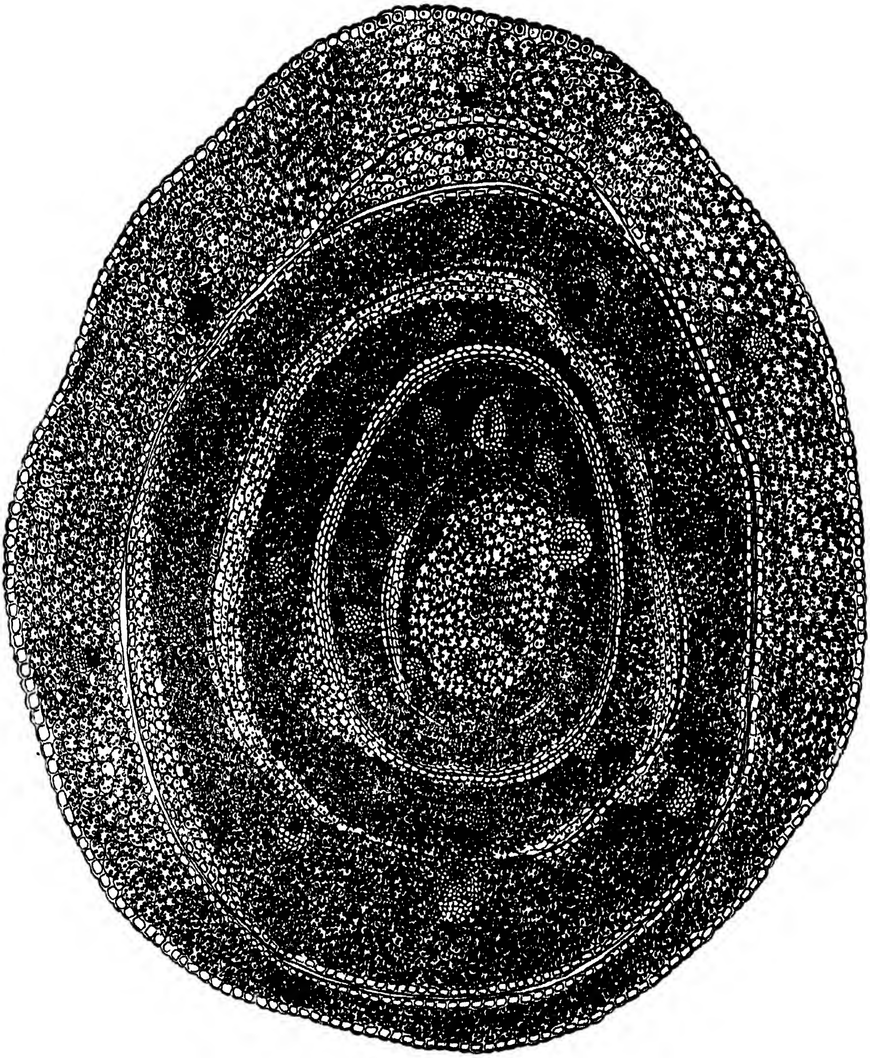


FIG. 23.—Transverse section of the hypocotyl of a young plant × 55.

the upper portions of younger leaves with the starch-granules replaced by chloroplasts, and the third side absent. The leaves are spirally arranged, the fourth leaf being vertically above the first.

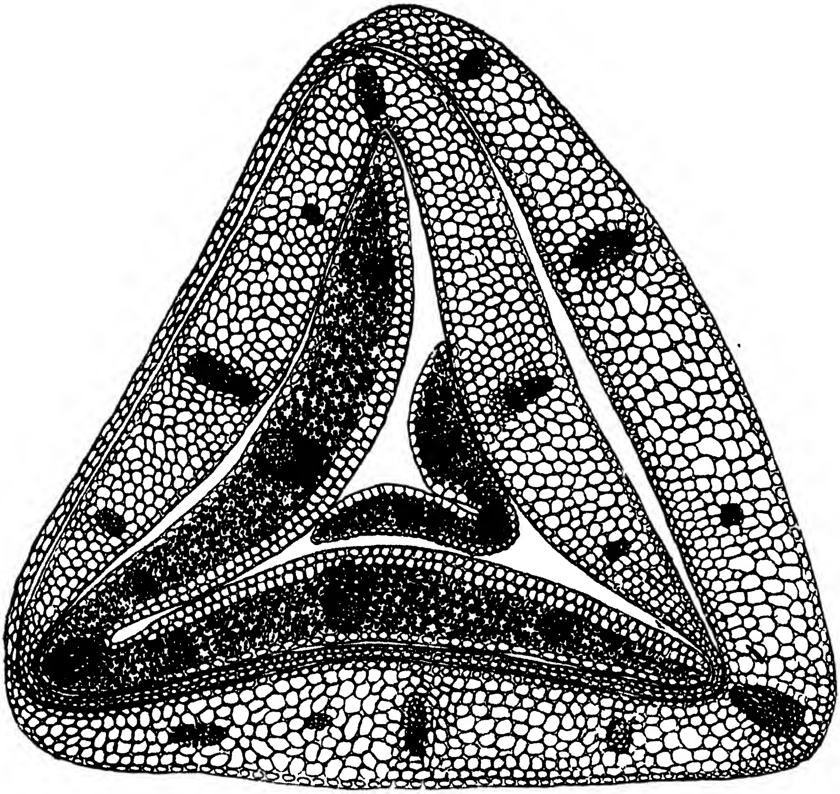


FIG. 24.—Transverse section through the leaf-bases of a young plant × 60.

SUMMARY.

Astelia nervosa var. *sylvestris* has certain well-defined xerophytic structures. There is a conspicuous aqueous tissue, and the chlorenchyma is composed entirely of spongy parenchyma containing very few air-spaces. The leaves are almost vertical, hairy at the base, and are combined to form tufts, the base of which serves to collect and store water. It is possibly due to this adaptation that the root system is not extensive. The leaf-bases and hypocotyl form a storage-place for food as is indicated by the copious starch in these regions. The functions of the hypocotyl are therefore the same as those of *A. Solandri* (Wilson, pp. 259, 262). These xerophytic characteristics of the mesophytic *A. nervosa* var. *sylvestris* are probably due to the fact that the genus which, as a whole, contains so many epiphytes, has a tendency towards xerophily.

The ovule resembles the typical monocotyledonous type, being anatropus and having two integuments. The embryo-sac is smaller than in most Liliaceae, and the nucellus is correspondingly larger, and surrounds the large central cavity at the base of which is the star-shaped structure which can still be seen in young seeds. The tongue-shaped projection of the base of the nucellus into the chalaza can only be seen in a median section, and is probably a nutritive device.

REFERENCES.

Betts, M. W., "Notes on the Autecology of Certain Plants of the Peridotite Belt, Nelson." *Trans. N.Z. Inst.*, vol. 52, pp. 276-314.

Cheeseman, T. F., *Manual of the N.Z. Flora*, pp. 312-319.

Herriott, E. M., "On the Leaf Structure of Some Plants from the Southern Islands of New Zealand." *Trans. N.Z. Inst.*, vol. 38, pp. 377-422.

Wilson, J. H., "Some Crevice Plants from the Lava-Field at Mt. Wellington." *Trans. N.Z. Inst.*, vol. 58, pp. 255-263.

Three New Recent Volutes from New Zealand.

By A. W. B. POWELL.

[*Read before the Auckland Institute, 29th May, 1928; received by Editor, 31st May, 1928; issued separately, 30th August, 1928.*]

PLATE 53.

THE larger Recent Volutes of New Zealand are separable into two main groups. One of shallow-water occurrence showing considerable variation, characterized by a projecting callus-plate on the columella; and the other from deeper water showing slight variation, characterized by a straight pointed columella, without callus-plate.

To the former group belong the species *arabica, swainsoni,* and *depressa* and to the latter, *jaculoides, larochei,* and two of the new species described below.

The writer is greatly indebted to Dr. J. A. Thomson and Dr. J. Marwick for the loan of valuable material, to Dr. E. N. Drier for the donation of a specimen as type, and to Mr. H. Hamer for his care and skill with the photography.

Alcithoe swainsoni Marwick (Figs. 1 and 2).

A figure of the holotype, an Upper Pliocene fossil from Kai-iwi is here given, as Marwick was unable to include it in his paper (2p. 294). He states that the division of the *arabica-swainsoni* group of shells into satisfactory species is a difficult matter.

The writer, however, has observed that typical *arabica* is quite constant throughout the Auckland and Manukau Harbours and Hauraki Gulf down to 25 fathoms; while *swainsoni* is the ruling shallow-water type in Wellington Harbour, though but a short distance away at Waikanae both *swainsoni* and *arabica* appear to intergrade.

A figure of a Wellington Harbour specimen (Fig. 2) is given for comparison with the Pliocene type (Fig. 1).

A very distinctive *depressa*-like variety of *swainsoni* occurs at Muriwai on the West Coast. For many years damaged shells were observed washed up on the sandy beach, and others wedged among the rocks. Recently three live specimens were collected. All are quite constant in having a depressed spire with weak shoulder-nodules, almost on a line with suture, and in the colour-pattern being weak or entirely wanting. They seem to represent a local race, not observed elsewhere, and are well worthy of subspecific distinction.

Alcithoe swainsoni motutarensis n. subsp. (Figs. 3 and 4).

Shell solid, moderately large. Whorls 5, exclusive of damaged protoconch. Spire low, conic, less than ⅓ height of aperture. Post-nuclear spire-whorls faintly nodulous, angled below towards lower

suture, body-whorl devoid of nodules. Suture almost on a line with shoulder tubercles, which are rather small, regularly spaced, and laterally compressed. Shoulder steep, almost straight. Body-whorl large, inflated. Fasciole prominent, marked off by defined ridge. Aperture large, open, deeply notched below, sub-angled above towards posterior notch. Outer lip thickened and reflexed, ascending less than ⅓ height of penultimate whorl. Columella vertical with large projecting callus-plate and 6 plications, upper two weak, lower four very strong. Inner lip spread as a thin glaze broadly over body-whorl, with prominent callosity towards posterior notch. Colour uniform pinkish-buff, with a very obscure pattern in the form of zigzag lines of darker buff, entirely absent towards outer lip. The paratypes show no traces of colour-pattern.

Height, 93.5 mm.; diameter, 42.5 mm. (holotype).

Height, 74 mm.; diameter, 33 mm. (paratype).

Habitat Motutara and Muriwai Beach, West Coast, Auckland (A.W.B.P.).

Holotype and two paratypes in Author's collection, Auckland.

Alcithoe calva n. sp. (Figs 5 and 6).

Shell very large, narrow and elongated. Whorls 8½. Protoconch scaphelloid, moderately large of 2½ smooth whorls. Post-nuclear whorls smooth, devoid of sculpture except in rare instances where spire-whorls are faintly shouldered, showing traces of axial costae. Spire tall, half the height of aperture, whorls slightly convex. Body-whorl elongate, sub-cylindrical, gradually contracted below to rounded fasciole, not marked off by usual ridge. Aperture long, rather narrow with shallow notch below. Outer lip thickened, reflexed above, ascending about ⅓ height of penultimate whorl. No projecting callus-plate on columella which is straight, tapering to a sharp point below, with six comparatively weak, very oblique plications; upper one more or less rudimentary. Inner lip spread as a thin glaze broadly over body-whorl.

Colour pale buff, ornamented with indistinct irregular light brown zigzag lines. Interior of aperture pinkish-fawn.

Most specimens have the outer surface badly eroded.

Height, 173 mm.; diameter, 64 mm. (holotype).

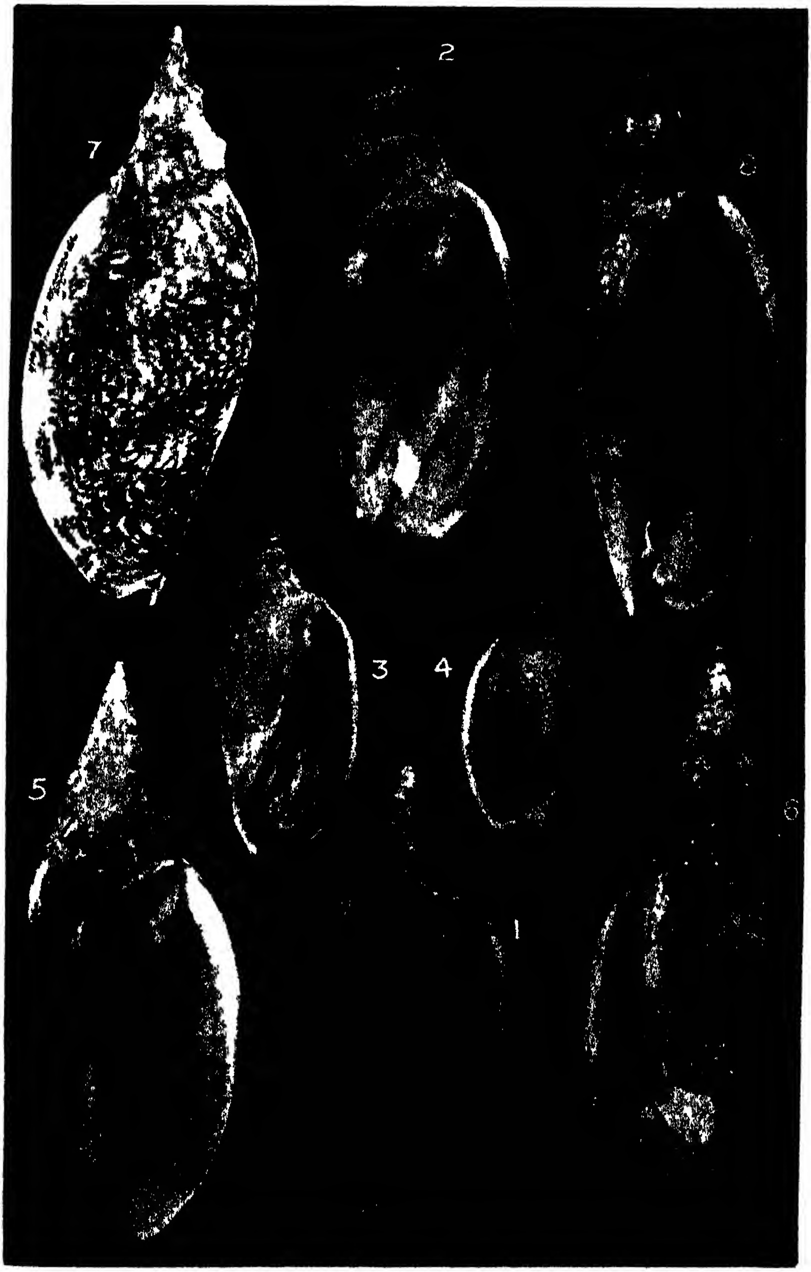
Height, 177 mm.; diameter, 64 mm. (paratype).

Habitat off Cape Campbell, Marlborough in 40-50 fathoms (H. Hamilton, 1925). Castlecliff, Wanganui (Upper Pliocene) 1 sp. (A. W.B.P. Jan. 1927).

Holotype and 21 paratypes in Dominion Musuem, Wellington.

This species differs from *swainsoni* in the elongated shape, weak columella plications, shallow anterior siphonal notch, and absence of projecting columellar callus-plate. Another related species, *larochei* Marwick, is distinguished by its broadly-fusiform shape and fewer and stronger columellar plications.

Both *larochei* and *calva* n. sp. occur commonly at Cape Campbell but do not seem to intergrade.



1. *Alcithoe swainsoni* Marwick (holotype) 145 mm. × 61 mm.
2. *Alcithoe swainsoni* off Rona Bay, Wellington Harbour, 179 mm. × 70 mm
3. *Alcithoe swainsoni motutaraensis* n. subsp. (holotype) 93.5 mm. × 42.5 mm.
4. *Alcithoe swainsoni motutaraensis* n. subsp. (paratype) 74 mm. × 33 mm.
5. *Alcithoe calva* n. sp. (holotype) 173 mm. × 64 mm.
6. *Alcithoe calva* n. sp. (paratype) 177 mm. × 64 mm.
7-8. *Alcithoe johnstoni* n. sp. (holotype) 169 mm. × 65 mm.

Alcithoe johnstoni n. sp. (Figs. 7 and 8.)

Shell very large, elongate, inflated below. Whorls $8\frac{1}{2}$ Protoconch scaphelloid, moderately large, of $2\frac{1}{2}$ smooth whorls. Postnuclear spire-whorls angled at centre and prominently nodulous. Penultimate whorl with 11 strong laterally compressed nodules. Shoulder sloping slightly concave. Body-whorl large, inflated, smooth and devoid of nodules, merged into fasciole without any defining ridge. Spire rather short, less that half height of aperture. Aperture long, expanded at centre, contracted above and below. Anterior siphonal notch shallow. Outer lip thickend and reflexed, uniformly broadly arched, ascending over half height of penultimate whorl. No projecting callus-plate on columella, which is straight, tapering to a sharp point below, with five strong oblique plications. Inner lip spread as a thin glaze broadly over body-whorl. Colour pale pinkish-buff, covered with a network of reddish-brown zigzag lines, becoming heavier and blotched at regular intervals, forming definite spiral bands, two on spire-whorls, four on body-whorl. Parietal callus and interior of aperture uniform pinkish-buff.

Height, 169 mm.; diameter, 65 mm.

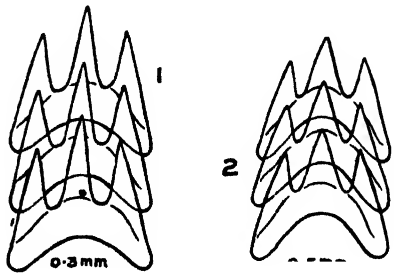
Habitat off Cuvier Island, in 44 fathoms.

Holotype in Author's Collection and two specimens in collection of Dr. E. N. Drier, Auckland.

This species is named in honour of Captain Fred Johnston of S.T. "Thomas Currell" who obtained the specimens. It resembles *jaculoides* in form of spire and columella but differs in the smooth inflated body-whorl and broadly arched outer lip.

RADULA.

The extremely simple degenerate radulae of the *Volutidae* are of little use for classification, as, in the majority of the genera (based on nuclear characters) only the central tooth remains, and it is almost invariably tricuspid. *Alcithoe* has this common type of radula but it is possible to detect minor specific differences in the form of the tooth and its cusps as illustrated by the accompanying diagrams.



1. **Represents 3 of the 69 rows from the radula of *Alcithoe arabica* (Puketutu Island, Manukau Harbour, on tidal mud-flats. Three radulae compared, characters found constant).**

2. Represents 3 of the 86 rows from the radula of *Alcithoe johnstoni* (paratype).

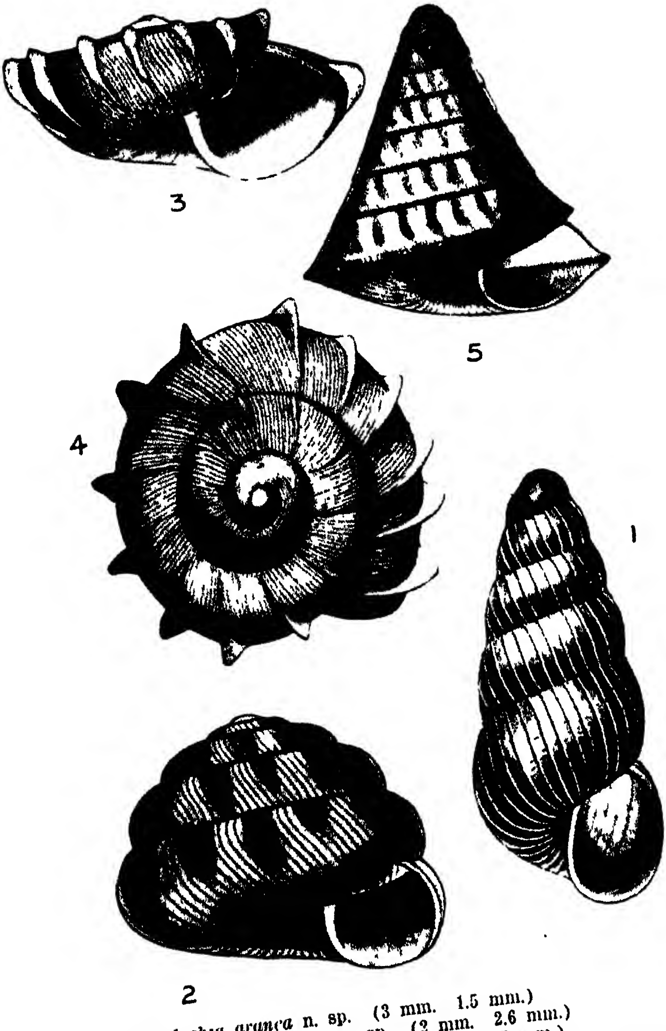
Compared with *arabica* the individual teeth of *johnstoni* are more deeply excavated at base and the cusps are shorter and stronger.

List of New Zealand Recent Volutes.
(with references).

Waihaoia (Pachymelon) lutea (Watson) (4, p. 449 & 2, p. 282).
Iredalina mirabilis Finlay (1, p. 59).
Alcithoe arabica (Martyn) (4, p. 445).
Alcithoe depressa (Suter) (4. p. 447).
Alcithoe jaculoides (Powell) (3, p. 108).
Alcithoe swainsoni Marwick (2, p. 294).
Alcithoe swainsoni motutaraensis n. sub sp.
Alcithoe larochei Marwick (2, p. 294).
Alcithoe calva n. sp.
Alcithoe johnstoni n. sp.
Alcithoe gracilis (Swainson) (4, p. 448).
Alcithoe hedleyi (Murdoch & Suter) (4, p. 448).

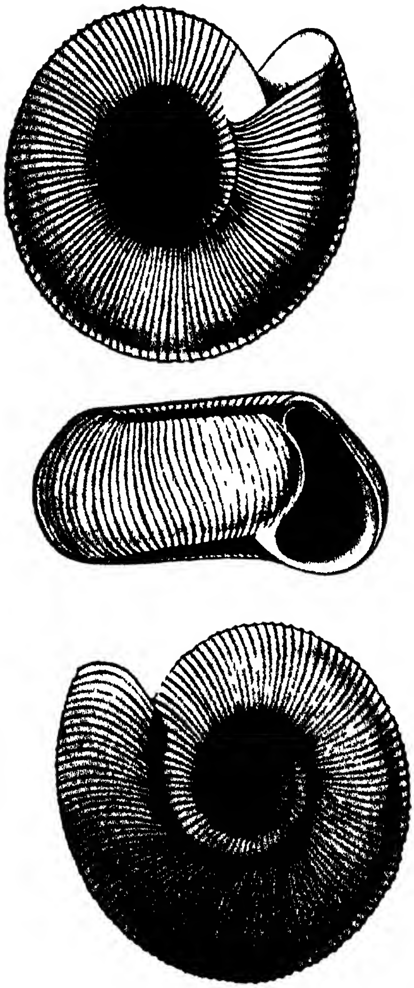
LITERATURE CITED.

1. Finlay, H. J., 1926. On *Iredalina* a New genus: A Volute without plaits. *Pro. Mal. Soc.*, vol. 17, pt. 1, pp. 59-62.
2. Marwick, J., 1926. Tertiary and Recent *Volutidae* of New Zealand. *Trans. N.Z. Inst.*, vol. 56, pp. 259-303.
3. Powell, A. W. B., 1924. Description of a new subspecies of *Alcithoe arabica* Martyn from New Zealand. *Pro. Mal. Soc.*, vol., 16, pt. 2.
4. Suter, H., 1913. *Manual of the New Zealand Mollusca.*



1. *Murdochia aranea* n. sp. (3 mm. 1.5 mm.)
2. *Aeschrodomus worleyi* n. sp. (2 mm. 2.6 mm.)
3-4. *Egestula spectabilis* n. sp. (0.7 mm. 1.5 mm.)
5. *Laoma* (*Phrixgnathus*) *larochei* n. sp. (2.25 mm. 2.3 mm.)

Face p. 364.



6

6. *Cavellia spelaea* n. sp. (2 5 mm. 5.25 mm.)

Descriptions of Five New Land-Shells from New Zealand.

By A. W. B. POWELL.

[*Read before the Auckland Institute, 31st July, 1928; received by Editor, 3rd August, 1928; issued separately, 30th August, 1928.*]

PLATES 54-55.

Murdochia aranea n. sp. (Fig. 1).

Shell small elongate-conical, subperforate thin and fragile. Whorls 6 including moderately large papillate protoconch of two smooth whorls. Post-nuclear whorls sculptured with close, white, membranaceous, obliquely-retractive riblets, about eleven per millimetre, interstices with exceedingly fine irregular spiral wrinkles. Body-whorl large almost equal to half total height of shell, riblets continuous over base and converging into umbilical cavity. Spire tall, over 2½ times height of aperture. Peristome thin, discontinuous. Columella oblique, arcuate, a little reflected over narrow umbilical perforation. Colour dark reddish-brown, excepting the white riblets which stand out in sharp contrast.

Height 3 mm., diameter 1.5 mm.

Holotype and 3 paratypes in author's collection Auckland, 5 paratypes in collection of Mr. W. La Roche, Auckland.

Habitat: Opononi, Hokianga Harbour, under decaying leaves in native bush. (W. La Roche, April, 1928.)

Remarks: This species appears related to Suter's *torquillum*, but is easily distinguished by its much greater adult size and proportionately taller spire.

Aeschrodomus worleyi n. sp. (Fig. 2).

Shell small, conoidal-dome shaped, axially costate, widely umbilicated with rounded periphery and base. Whorls 5, including low rounded protoconch of 2 faintly spirally striated whorls. All post-nuclear whorls sculptured with prominent narrow, regular, closely-spaced, sharply raised, flexuous and retractive axial riblets, about 10 per millimetre. The interspaces crowded with exceedingly fine subsidiary axial threads and still finer close spiral threads, producing a fine even reticulation. Spire 1⅜ height of aperture. Whorls evenly convex, impressed at sutures. Base slightly flattened towards umbilicus which is wide and deep of about one-third of diameter. Aperture small subcircular. Peristome thin, discontinuous. Columella short, arcuate, slightly reflexed, and almost vertical. Parietal-wall covered with a thin glaze. Colour buff with irregular radial rectangular blotches of reddish-brown, becoming obsolete towards lower suture and not extending over periphery on body-whorl.

Height 2 mm., diameter 2.6 mm.

Holotype presented to Auckland Museum by Professor F. P. Worley.

Habitat: Near Baton River, Nelson (Professor F. P. Worley and Rev. F. Worley, 1897). Between Owen and Murchison, Nelson-West Coast Road (A. W. B. P., December, 1927). Under decaying wood in native bush.

Remarks: This species agrees very well with *Aeschrodomus* except that the riblets are not produced into hair-like processes at the periphery. The conoidal spire and striated protoconch however are typical characters discordant with the closely allied genus *Charopa*.

Egustula spectabilis n. sp. (Figs. 3 and 4).

Shell small, sub-discoidal, almost flat above peripheral angle, convex below, rapidly contracting over base into broad umbilical cavity. Whorls 3½, including protoconch of 1½ low, convex, finely spirally striated whorls. All post nuclear whorls covered with fine, close retractive axial riblets and regularly spaced, obliquely retractive radial lamellae, produced at periphery into broad bluntly-rounded thin plates, diminishing above towards suture and below towards umbilicus. Spiral sculpture in form of indistinct microscopic striae. Body-whorl slightly descending towards aperture. Aperture moderately large, rhomboidal. Peristome discontinuous. Outer lip thin, bluntly angled at centre. Parietal callus thin, crossed by two of the lamellae. Columella oblique, arcuate, slightly reflexed. Umbilicus about one-fifth width of base. Colour uniformly golden-brown.

Height 0.7 mm., diameter 1.5 mm.

Holotype presented to Auckland Museum by Professor F. P. Worley.

Habitat: Nelson (Professor F. P. Worley and Rev. F. Worley, 1897).

Cavellia spelaea n. sp. (Fig. 6).

Shell very large for the genus, discoidal, with sunken spire, broadly umbilicated and regularly radially costate. Whorls 4½, including smooth protoconch of 1½ low convex whorls. Post-nuclear whorls sculptured with numerous oblique, protractive, fine radial riblets about 9 or 10 per millimetre, persistent over whorls from spire to umbilicus. Interstices with exceedingly fine and close radial growth-threads. Body-whorl flattened above periphery, evenly convex below to broad perspective umbilicus, a little more than one-third width of base. Aperture pyriform, constricted above. Outer lip thin, protractive, overhanging above. Inner lip spread as a broad thin glaze over parietal wall. Basal lip slightly expanded and reflected at junction with parietal wall.

Height 2.5 mm., diameter, maj. 5.25 mm., min. 4.75 mm.

Holotype and six paratypes in author's collection Auckland.

Habitat: Coonoor Cave, near Dannevirke. Sub-fossil together with moa bones (*Dinornis*) and the common Recent bush snail, *Charopa coma* (Gray). (H. Hamilton, December 1914.)

Remarks: This is the largest species of the genus, readily distinguished by the flattened sides above periphery.

Laoma (Phrixgnathus) larochei n. sp. (Fig. 5).

Shell small, semitransparent, acutely conical. Spire slightly concave, almost three times height of aperture. Acutely angled and keeled at periphery, broadly umbilicated and rounded over base. Whorls 8, including rather large globular protoconch of 2 smooth whorls. Post-nuclear whorls scultpured with fine and close, retractive, arcuate growth-lines, much stronger on base. Suture distinct, margined above by a thread which later resolves into peripheral keel. The spire-outline is slightly concave and rendered a trifle gradate, due to the whorls coiling just under the keel. Base gently rounded. Umbilicus deep, rather narrow, about one-sixth diameter of base. Aperture rhomboidal. Peristome thin, discontinuous. Outer lip acutely angled at centre. Columella very short, vertical. Colour pale buff, semitransparent, regularly radially banded with light reddish-brown.

Height 2.25 mm., diameter 2.3 mm.

Holotype in author's collection Auckland, paratype in collection of Mr. W. La Roche, Auckland.

Habitat: Opononi, Hokianga Harbour, under decaying leaves in native bush. (Mr. W. La Roche, April 1928.)

Remarks: Related to the rare South Island *marginata* Hutton which, however, is less conical and has a much smaller umbilical cavity.

Notes and Descriptions of New Zealand Hymenoptera.

By E. S. Gourlay, First Assistant Entomologist, Cawthron Institute, Nelson.

[*Read before the Nelson Institute, 26th October, 1927; received by the Editor, 14th May, 1928; 30th August, 1928.*]

Ichneumonidae.

Limnerium Muelleri Butler.

Mesoleptus Muelleri Butler, Voy. Erebus and Terror, 1874, Insects, p. 27; Hutton, Cat. N.Z. Diptera, etc., 1881, p. 122.

Limneria zealandica Cameron, Man. Mem. 1898, p. 36.

An interesting account by C. M. Wakefield, of Christchurch, accompanied by figures, of the associations of *L. Muelleri* with the host, *Morova subfasciata* Walk., a gall-maker on *Muhlenbeckia australis* Meissn. is quoted by Butler on pp. 46-47. The Ichneumonids are found plentifully during the summer months flying around *M. australis,* assiduously examining the galls formed by *M. subfasciata.* A study of the habits of the Ichneumonids shows that they are seeking the small, round portion of epidermis covering the exit-hole of the adult moth. This is made by the moth-larva before pupating, and it is safe from the attacks of *L. Muelleri* until the exit-hole has been excavated through the thick wood of the gall. After the Ichneumonid larva has completed its metamorphosis it spins a rough, dark-brown, cylindrical, elongated, obtusely-rounded cocoon within the gall, and the adult escapes through the exit supplied by its host.

Empty galls are frequently utilized by other insects.

These include—species of *Hylaeus,* the larvae of which spin a transparent, hyaline envelope around the inside of the gall; as many as four have been discovered within one gall, though the average number is two.

Larvae of the peculiar beetle *Paupris aptera* Sharp, reside within the galls, and individuals may be collected *in situ* in all instars. When more than half grown, these larvae are easily reared by segregating them in pill-boxes and occasionally supplying small pieces of apple for food.

Other larvae inhabiting the galls are those of the native moth *Harmologa scoliastis* Meyr., although these, together with their puparia, are less common than *Paupris aptera.*

Wolf-spiders are casual occupants. Galls favoured by *Hyaleus* and spiders are always dry, while *P. aptera* and *H. scoliastis* prefer the living wood.

BRACONIDAE.

Aspicolpus Hudsoni Turner.

Recently Mr. R. E. Turner, of the British Museum, described this insect, the largest and finest Braconid known in New Zealand, from a male specimen submitted to him by Mr. G. V. Hudson, of Wellington. A number of specimens have been studied from the collections of Mr. G. V. Hudson, Mr. A. Philpott and the writer. Compared with the type, colour-variations are diverse, being inconstant in all parts but the thorax, the head, and antennae, and the venation. In three specimens the variations exist to such an extent that it has been considered necessary to designate a subspecies, *A. hudsoni castanea*, new var.

The subspecies does not differ from the type in any points but those of size and colouration, and therefore cannot receive specific rank. Except for the antennae anterior to the scape and the ovipositor-guides which are black, the insects are castaneous; the venation brown, with a black stigma; palpi pale brown; mandibles castaneous, teeth black.

Doryctes pallida n. sp.

♂. 7.75 mm. Head, scape, hind-coxae, all femora and tibiae light brown. Remainder of antennae, all tarsi, ocellar area, a large area at the back of the head and the abdomen, brown. Fore and mid-coxae, all trochanters and a small section of the tibiae basally, pale amber-coloured. Thorax mostly dark brown, approaching black. Mandibles concolourous with the head, teeth black.

Head shining, closely microscopically punctured, vertex and scape covered with apressed, amber-coloured pubescence; frons, clypeus, checks, and madibles frontally with longer silvery pubescence, longest on the last three.

Thorax with sparse silvery pubescence; pronotum dorsally and metanotum wholly rugulose; the rest closely, microscopically punctured. Lateral metanotal carinae indistinct, the median carina faint, indicated only basally. The basal four-fifths of area between the parapsidal furrows closely covered with apressed, amber-coloured pubescence diverging slightly from a central line, and pointing posteriorly.

Abdomen highly polished; first and second segments wholly longitudinally striate; the following also longtudinally striate: anterior lateral half of the third, most of the anterior lateral third of the fourth, and a small part anterior-laterally on the fifth.

Wings hyaline, stigma and venation dark-brown; suffused with dark-brown pigment, except two areas under the basal end of the stigma and two larger areas close to the apical end of the stigma. These areas are placed near the fore and hind-margins respectively. Hind-wings uniformly and only lightly suffused with brown.

Holotype (♂), Karori, Wellington, Autumn 1920, G. V. Hudson.

Paratype(♂), Whakapapa 4000 ft., Mt. Ruapehu, January, 1922, G. V. Hudson. Holotype in collection E. S. Gourlay, paratype in collection G. V. Hudson.

Encyrtidae.

Neosolindenia n. gen.

Female. Head large, transverse, as wide as thorax, shorter than broad, with moderately-excavated antennal furrows. Eyes oval, bare, slightly convergent above; an impressed line from base to insertion of mandibles. Ocelli a little below vertex, in a triangle. Antennae subclavate, not close together and inserted a little below eyes; scape not quite reaching front ocellus, curved; club obliquely truncate, hollowed ventrally.*

In front of the scutellum the mesonotum is depressed for one-third of its length, the depression then dividing into two narrowing furrows running to the pronotum but diverging laterally before reaching it. Axillae triangular, nearly meeting at their inner angles at base of scutellum which is roughly diamond-shaped. Thorax longer than abdomen; ovipositor exserted.

Front femora slightly swollen, broadest in apical third; middle tibiae with one spine and having a row of five thick black spines basally at the sides; middle tarsi moderately swollen with thick black spines on joints 1-3; hind-tibiae with a single spur.

Male. Resembles female in all but the following points: antennae not tapering; scape shorter; pedicel shorter and broader; flagellum broadly filiform, except for obliquely-truncate apical joint. Mesonotum normal, without depressions, and with indistinct paraspidal furrows running obliquely on their apical two-thirds to sides of mesonotum. Scutellum rounded basally. Middle tibiae and tarsi without spines, tarsi not dilated.

Closely approaches the genus *Solindenia,* from which it differs in having head as wide as thorax, eyes not oblong oval, especially convergent above, nor projecting beyond back part of head; ocelli not close to inner margin of eyes, and in having ovipositor exserted.

Neosolindenia cyanea n. sp.

♀ 3.75 mm.; valves of ovipositor extruded .75 mm. Ground colour black, with highly metallic deep blue tints, except where otherwise stated.

Antennae short, the flagellar joints widening consecutively to apical which is conical; covered with apressed, thick, black hair; apical joint possessing short, thick, sensory hairs, visible only under high magnification. Eyes black; ocelli transparent golden-brown. Head finely reticulate, except on vertex which is rugulose; with a few short black hairs on vertex, long and pale-brown on face.

Thorax finely reticulate; except on mesopleurae covered lightly with silvery hairs; a fringe of apressed long, stiff, black hairs on pronotum basally. Wings iridescent, veins dark-brown.

Legs more hairy than thorax; anterior and middle femora with knees and adjoining parts of tibiae, brown; first anterior tarsal joints partly, remainder, wholly dark-brown, last darkest. Middle and hind tarsi differ by anterior half of the first joint being lighter. Tibial spur on middle legs light brown, spines under tarsal joints 1-3 black.

*Possibly occurring only after death, but consistently formed in all specimens examined.

Ovipositor transparent brown; a small anterior part of guides black, the rest consecutively and evenly divided into honey-yellow and dark-brown.

♂ 2.3 mm. Like the female, but differs in minor characters, viz: no sensory hairs on apical joint of antennae; first tarsal joint of middle and hind legs a dirty cream with a slight suffusion of black apically; spur of middle tibiae silvery.

This Chalcidoid is parasitic on *Limneria mulleri* Butl. adults emerging from cocoons of the latter.

Holotype (♂), Nelson, collected 31/7/27, emerged 1/12/27, E. S. Gourlay. In collection Cawthron Institute.

Allotype (♀), Nelson, collected 31/7/27, emerged 27/10/27, E. S. Gourlay. In collection E. S. Gourlay.

Paratypes, a series of nine females and three males. One female was taken by Mr. A. Philpott in Nelson on 7th February, 1921. The following is a record of specimens taken by the writer: six females from Nelson at dates between December 1924 and November 1927; one female from Murchison, 26/1/27, and one from Riccarton Bush, Christchurch, 7/1/24; three males from Nelson, between November and December, 1927.

Polymoria barteli n. sp.

♀. 6.5 mm.; valves of ovipositor large and flattened, extruded 1 mm. Ground-colour black, with various metallic colours superimposed, frequently to such an extent that the grand-colour has a darkening influence only.

Antennae 12-jointed, black, sparsely clothed with pale short hair, shorter on flagellum; scape curved, slightly reflecting a golden iridescence, pedicel reflecting a rosy iridescence. Head coarsely rugose, finer at ocellar area; face, clypeus, base of clypeus fringed above mandibles except in centre, lower cheeks and palpi, with long silvery hair; at the back basally, sparse long black hair; reflecting subdued golden and rosy metallic colours; mandibles black.

Pro- and meso-thorax rugose, with a few scattered hairs; the former subdued metallic greenish-gold; mesothorax rosy and blue metallic on each side of and between parapspidal furrows; the latter greenish-gold, green predominating; the metathorax and episternum finely rugose; spiracles large, oval; tegulae testaceous.

Wings iridescent, the fore-wings with a medial longitudinal fuscous band; veins fuscous, post-marginal vein twice as long as stigmal.

Knees of femora, tibiae, and tarsi fuscous; last three joints of tarsi and claws darker. Abdomen one and a half times length of thorax, reticulate; possessing a fimbria of a few long black hairs, the other segments scantily covered with short silvery pubescence; metallic greenish-gold with blue, purple and rose tints dorsally on segments 4-6; segments 1 and 2 scaly; greatly incised medially in 1, less in 2.

♂. 4 mm. Differs from female in the following points; antennae 10-jointed; scape shorter; flagellum not hairy, flattened, longitudinally striate. The infuscation in wings is less apparent. The anal fimbria is absent, and there are a few long, pale hairs on abdomen.

In a series of 18 males and 79 females there is great diversity in size, the former ranging from 2 mm. to 4.75 mm. in length, the latter from 4 mm. to 6.5 mm. in length.

Named after Mr. J. G. Bartel, of Nelson, who kindly permitted the writer access to his private property, where a large series of this species was collected. The host is at present unknown.

Holotype (♂), Nelson, 21st October, 1925, E. S. Gourlay. In collection Cawthron Institute.

Allotype (♀), Nelson, 2nd November, 1927, E. S. Gourlay. In collection E. S. Gourlay.

Partypes, a large number of specimens, enumerated above, taken in Nelson between October 1921 and November 1927, collected by J. G. Bartel and E. S. Gourlay, also a male with the wing-fascia absent, taken by the writer at Riccarton Bush, Christchurch, on 6th October, 1920; four females secured by Mr. A. Philpott in Nelson,

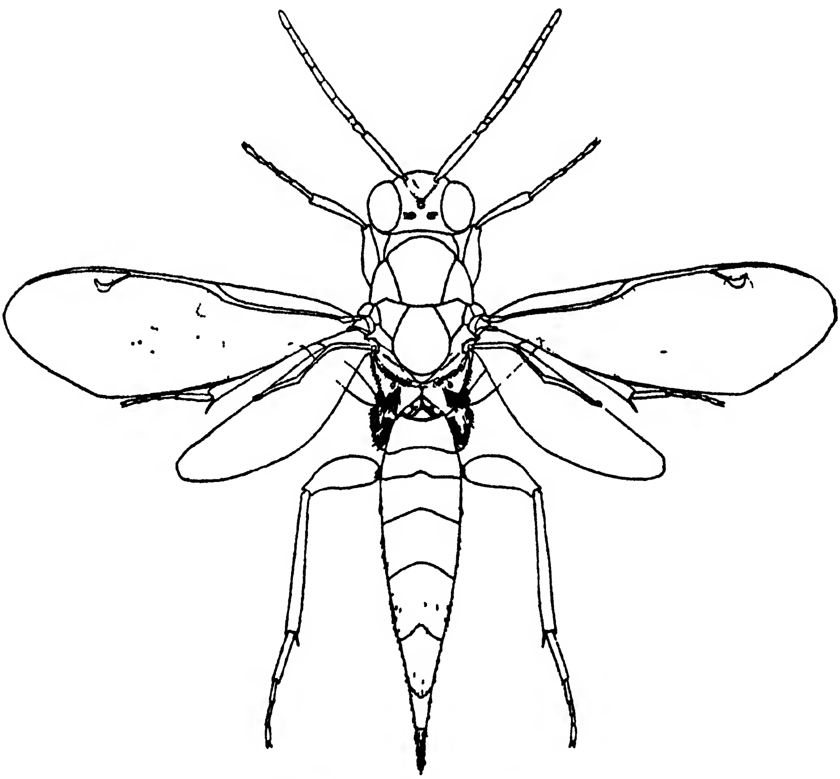


FIG. 1.—*Thaumasura resplendens* n. sp Disposition of hairs indicated only on metathorax, hind covae and abdomen.

between 3rd October, 1921 and 10th October, 1922, and two females collected by Mr. G. V. Hudson at South Karori, Wellington, 30th November, 1921 and at Makara Bush, Karori, Wellington, 5th December, 1925.

CLEONYMIDAE.

Thaumasura resplendens n. sp. (Fig. 1).

♀. 8 mm.; to tip of ovipositor 8.5 mm.

Head transverse, roughly triangular, with vertex dull green, the rest, with scape and pedicel of antennae, metallic red and green; remainder of antennae black.

Pro- and meso-thorax dull green, finely reticulate and having a quilted appearance; metallic green, gold and pink ventrally; metathorax and first abdominal segment shining black, the former with areas around spiracles of brilliant metallic-green bordered with red, and having a fringe of very long silver hairs disposed laterally and basally.

Abdomen brilliant metallic-red dorsally, black and slightly metallic ventrally. Legs brown, with coxae and claws black, the former metallic-green, gold and pink underneath. Wings hyaline, venation brown; a small brown fascia distally below the submarginal vein; a larger brown fascia from the stigma, curving downwards and towards base of wing, terminating closer to base of wing than the smaller fascia. Guides of ovipositor black.

Closely approaches the Australian species *T. silvensis* Gir. but differs in the distance between the eyes at the vertex being twice that of *T. silvensis*, the ovipositor scarcely exserted, in the wing-fasciae and minor points of colouration. On the whole, the two species are strikingly similar.

Holotype (♀), Karori, Wellington, 17th January, 1909, G. V. Hudson. In collection G. V. Hudson.

Paratype (♀), Leslie River, Mt. Arthur, 17th November, 1925, W. Heighway. In collection Cawthron Institute.

Studies in New Zealand Fishes.

By L. T. Griffin, F.Z.S., Assistant Curator, Auckland Museum.

[*Read before the Auckland Institute 29th May, 1928; received by Editor, 4th June, 1928; issued separately, 30th August, 1928.*]

Plates 56-65.

Family Muraenidae.
Genus Gymnothorax Bloch.

Gymnothorax nubilus (Richardson). (Fig. 1).

Muraena nubila Rich. *Voy. Ereb. & Terr.* Fish. p. 81, pl. 46, Figs. 6-10.
Muraena petelli Bleeker. Guenther, *Cat. Fish. Brit. Mus.* p. 105.

Head, 3.28 in trunk or nearly 7 in total length of fish. Eye, 10 in the head or 2 in snout. Gill-opening sub-equal with the eye. Anterior nasal tube, about ¾ the eye. Mouth, rather more than 2 in the head. Dorsal fin, 2 in greatest height of body. Teeth in jaws broadly compressed, 12 on each side of the upper jaw, with 3 shorter ones in front, and 13 on each side of the lower jaw, with 2 small ones in front. Minute intermediate teeth present between each of the larger series. A single long palatine tooth followed by a mesial line of about 10 small ones, the third of which is longest, the last three or four very minute.

Body compressed, tapering gently to tip of tail. Occipital region slopes steeply from origin of the dorsal fin to tip of snout. Snout convex, flattened on sides with a slight concavity behind the eye. Anterior nostrils in a moderately stout tube the tips of which are turned inwards. Posterior nostril a small lanceolate slit situated above the anterior margin of the eye. Branchiostegal sac very little developed.

Origin of dorsal fin is the vertical from the centre between the eye and gill-opening. The fin is almost of uniform height throughout, except where it aproaches the tip of tail. The anal originates immediately posterior to the vent, it is much lower than the dorsal, its greatest width being about half the height of the former. Tip of tail entirely surrounded by the fins.

Colour: Uniform ochraceous tawny of Ridgway's colour standards plate 15, the ventral surface being mineral-grey, pl. 47 of the same work.*

A series of fourteen or more rather indistinct nebulous blotches on the sides which do not extend on to the dorsal fin. Sides of head and lower jaw lighter than the body-colour. Three very black lines on side of head, the first originating at angle of mouth nearly reaching gill-opening, the second in line with middle of lower jaw, while the third passes along its lower margin. Dorsal fin uniform, same as body-colour for three-fourths of its length, then becoming

**Colour Standards and Nomenclature.* Ridgway, Washington, D.C. 1912.

very narrowly margined with black, and with an outer very thin line of pure white. Base of anal greyish-brown broadly margined with black and white. Eye bright bluish-silver with an oblong blue-black lens.

Identity and variation: I have managed to secure only one specimen of this striking eel, which, so far as I am aware, is the first example recorded from New Zealand. The description and plate given by Richardson agree so well with my specimen, that despite very minor differences, I have no doubt as to its correct identity. It is well known that the dentition and other characters are liable to great change with age in all members of this family. In Richardson's fish, the teeth are somewhat greater, while the colour-marking seems much more clearly defined; but beyond this my fish is comparative.

It seems questionable whether *Muraena petelli* Bleek, should be regarded as conspecific.

Mr. Gilbert Whitley, Zoologist to the Australian Museum, informs me that *Gymnothorax patelli* (Bleeker) was originally described from "Ora Malang," Java, and seems to be restricted to the tropics (Vide Weber & de Beaufort, Fish. *Indo Austr. Archip.*, 3, 1916, p. 372), and is perhaps distinct from *G. nubilus* (Rich.) from Norfolk Island.

Described and figured from a specimen which is 640 mm. long from the tip of snout to tip of tail. Greatest width of body 55 mm.; eye, 9 mm.; gill-opening, 9 mm.; angle of mouth, 40 mm.; dorsal fin, 27 mm.; anal fin, 15 mm.

Locality and distribution: Sister Rocks, near Cape Brett, Bay of Islands, March 1928. Richarson records it from Norfolk Island, while Guenther records it from the Indian Ocean and Achipelago.

Specimen in the Auckland Museum.

Family TRACHICHTHYIDAE.
Genus HOPLOSTETHUS Cuv et Val.

Hoplostethus elongatus (Guenther). Long Roughy. (Fig. 2).

Trachichthys elongatus Guenther. *Cat. Fish. Brit. Mus.*, 1, p. 10, and *Voy. Chall. Zool.*, vol. 22, p. 22, pl. V, Fig. C.

Br. 9; D.iv/XI; A.iii/IX; V.i/VI; P.XI; C.xix/5/5; L. lat. Ca65-70 L.tr about 19 above and 27 below. Abdominal scutes 10-11. Depth of body rather more than $2\frac{3}{4}$ in the length to the hypural joint; head, 3.14 in same. Eye, $2\frac{1}{2}$ in the head or 1.5 in the caudal peduncle. Interorbital space equals 2 of the eye. Snout, $\frac{1}{2}$ the diameter of eye.

Body compressed, dorsal and ventral profiles fairly evenly curved, covered with rather small ctenoid scales, and with a strongly serrated abdomen. Lateral line commencing at upper angle of operculum curves downward for a short distance over pectoral, thence straight to caudal. Cheeks and maxillary with small ctenoid scales similar to those on body. On the operculum scales are present on its upper margin, and below these there are several broad, roughened arched ridges about the centre, with a smooth transparent flap behind ending in a broad flexible point. A moderately strong

spine present on its upper posterior margin. Praeoperculum with two parallel bony ridges on its posterior margin, the edges of which are strongly roughened, and end with a strong spine at the angle, the latter not quite reaching the gill-opening. Humeral bone smooth.

Interorbital space convex. Scales on the nape extend forward to above middle of eye, thence to tip of snout no scales are found, but the skin is roughened. Two narrow bony ridges from nape to tip of snout converging in middle with a narrow triangular cavity above eye. Between these and the superciliary margin, there is a strongly-arched ridge curving from the suprascapulary to the posterior nostril. Nostrils close together, the anterior small, rounded, the posterior larger, ovate. Eye large, placed high up on side, the infraorbital arch transformed into a channel covered by semi-transparent skin, and crossed by five or six roughened bony ridges. Snout short, rounded, the cleft of mouth oblique. Exceedingly fine villiform teeth in a narrow band in both jaws. A very minute patch on the vomer, and a narrow band on the palatine bones. Maxillary extends backward to vertical of posterior margin of eye or a little beyond. It is elongate, styliform, but dilated at the end. Lower jaw little shorter than the upper with two small roughened points in front.

Gills 3½; gill-rakers long, slender, 19 on the lower half of the anterior limb. Pseudobranchiae present. Origin of dorsal fin much nearer to tip of snout than to the caudal, the third ray highest, those following getting progressively shorter. The anal originates in the vertical of tenth ray of dorsal to which it is similar in form. Pectoral rounded, sub-equal in length to ventral. Caudal moderately forked, lobes pointed.

Colour: Dorsal above lateral line deep violet-brown, below, silver lightly shot with violet. Base of dorsal and anal bright orange, the rest clear. A broad streak on each lobe of the caudal bright orange, rest of tail clear. Pectoral and ventral bright orange at base, the rest clear. Head similar to body-colour. Eye golden-orange and blue-black.

Described and figured from a specimen which is 83 mm. long from tip of snout to hypural joint. The head is 29 mm., eye 10 mm., caudal peduncle 12 mm.

Locality: Kawau Island, Hauraki Gulf, Jan. 1928. Several specimens presented by Mr. Harold Buddle. Specimens in the Auckland Museum.

Family Stromateidae.
Genus seriolella, Guichenot.

Seriolella amplus n. sp. (Fig. 3).

Key to the New Zealand Species.

a. Body compressed, deep. Nostrils near end of snout.
Maxillary reaching to or little beyond the vertical from anterior margin of the eye. Ventrals rather small.
A conspicuous dark patch on body near the upper posterior margin of operculum. Pectoral reaches beyond the vent, or to the vertical of the 14th dorsal ray ... *S. brama.*

aa. Body elongate, not so deep, with numerous small round spots along the middle line. A dark vertical bar across the eye. Pectoral

reaches the vertical of the 8th dorsal ray, and not nearly reaching the vent *S. punctata.*

b. Body robust. Nostrils about midway between the eye and tip of snout. Maxillary reaches just beyond the centre of eye. Pectoral markedly falcate, reaching backward to the vertical of the 8th-9th dorsal rays, and to the anterior margin of the vent. No dark patch on body at upper posterior margin of operculum *S. amplus* n. sp.

Br. 7; D.ix/I/XVIII; A.iii/XV; V.i/V; P.XIX; C.XXII.

Depth behind ventral, 3.21; head, 3.12 in the length to base of caudal rays. Eye, rather more than 4.8 in the head, subequal with snout, and nearly 2 in interorbital space. Caudal peduncle subequal with width of eye. Line lat. about 100, L.tr 30 above 33 below.

Body robust, the dorsal and ventral profiles almost equally arched, covered with rather small cycloid scales, which become somewhat larger about the centre of the fish behind pectorals. The cheeks, operculum, and interoperculum, are also covered with moderate scales, which terminate in a line with the upper margin of the orbit, but the broad margin of the preoperculum, maxillary, lower jaw and preorbital, are scaleless. Top of head smooth, excepting an isolated patch of small scales situated about midway between top of orbit and profile. There is also a band of imbedded scales above the eye on margin of orbit. The scales behind the eye form a double band of a leaf-like pattern, and there is a similar group at angle of jaw, while scales on cheeks are ranged in more or less narrow curved bands.

Lateral line convex over pectoral, concave below second dorsal, thence slightly oblique to caudal. On peduncle it is nearer to ventral surface than dorsal.

Snout covered with very tough skin. Two nostrils placed nearly in the centre, or rather nearer eye than tip of snout. Maxillary covered with tough skin similar to snout, of moderate strength, and reaches a little beyond vertical of centre of eye. Preorbital narrow, its margin smooth. Mouth oblique, lips and lower jaw covered with very tough skin. Teeth in jaws in a single series, none on vomer, palatine bones, or tongue. Eye large, situated nearer top of head than middle. Preoperculum finely denticulated, emarginate, angle produced and broadly rounded. Operculum terminating in a thin flat point margined with skin. Gills, 4; gill-rakers, 17 on lower half of anterior limb. Pseudobranchiae present. Dorsal fin commencing somewhat behind the vertical of base of pectoral stands in a shallow groove, spinose portion strong, and much lower than rays; spines get progressively longer from the first to the fifth-sixth which are longest, subequal with the last, or ⅘ width of eye. The first ray is simple and highest, those following are branched. First two spines of anal are extremely small and difficult to detect, being almost completely embedded in thick membrane of fin, they are firmly adherent to third spine which is adherent to first ray, the latter being simple, similar to first ray of dorsal. Both fins are similar in character and form, heavily scaled at base, and between interradial membranes. Pectoral markedly falcate, reaching backwards to vertical of eight-ninth rays of dorsal. Ventrals rather large, furnished with a long slender spine; they extend backwards to vertical of eighth dorsal spine. Caudal forked, rays covered with scales for three-fourths of their length.

Colour: Above lateral line, bluish-black, some specimens showing a brownish hue. Below lateral line, dull silver shot with pale blue. Top of head same as body above lateral line. Cheeks and opercles, dull silver shot with pale blue. No dark blotches are found on this species, and the conspicuous black blotch seen on upper margin of operculum in *S. brama*, is totally absent in this fish. The naked margin of preoperculum, maxillary, and lower jaw have many minute cream-coloured dots, and a few light blotches irregularly scattered about. Pectoral very thin bluish-horn colour. Dorsal, anal, ventrals, and caudal, similar to body-colour. Eye, golden with an inner black ring, the membrane covering the eye being transparent bluish.

Described and figured from the holotype which is 537 mm. long, from the symphysis of the lower jaw to the hypural joint. The head is 183 mm. long, the eye 39 mm., ventral 28 mm., pectoral 161 mm., width of caudal peduncle 48 mm.

Affinities and variation: When I first glanced at this fish, I thought it would turn out to be merely a variety of *S. brama*, as it is well known that the latter species is subject to very great variation; but a more critical examination soon proved this to be incorrect. Since obtaining the holotype, I have examined many others of various sizes, and the closest observation failed to show any variation whatever. This is interesting when we realize the great differences found in other species in the same genus. It is somewhat extraordinary that this fine fish has never been brought to the notice of scientists before, as it appears to be very plentiful in its habitat. It is, however, strictly local; this will probably account for its absence in the markets. Many specimens have been taken recently on the line by Mr. Shirley, one of our most observant fishermen, who informed me that he had happened upon an old Maori fishing ground, the history of which was well known to present-day Maoris, but the locality had been forgotten for many years. Mr. Shirley found the place teeming with hapuku, *polyprion prognathus*, and the species which forms the subject of this description. Not very far away a second ground was discovered, where both species were found also, though not quite so plentiful. I owe Mr. Shirley my thanks for bringing this interesting fish to my notice.

Locality: Near Mayor Island, Bay of Plenty. Taken by hand line on a very rocky bottom. Holotype and paratype in the Auckland Museum.

Family BRAMIDAE.
Genus BRAMA, Bloch & Schneider.

Brama raii (Bloch). Ray's Bream. (Fig. 4).

Sparus raii Bloch, *Ausl. Fische.* 5, 1791, p. 95, pl. 273.
Brama squamosa Hector. *Trans. N.Z. Inst.*, 9, 1877, p. 465, pl. 9, Fig. 32a.
Brama raii (Bloch). McCoy, *Prodr. Zool. Vict.* 14, 1887, pl. 133.
Brama raii (Bloch). Phillipps, *N.Z. Journ. Sci. & Tech.* 7, p. 246 with fig.

Br. 8; D.iii/XXXII; A.ii/XXVI; P.xix; V.i/V; C.xxiii. Line lat. 90; L.tr, 14 above, 28 approx. below.

Depth of body, 2.10½ from tip of snout to base of middle caudal rays; head, from symphysis of lower jaw 3¾ in same. Eye, 3¾ in the head, and nearly equal to the snout. Caudal peduncle ⅘ the width of eye.

Body greatly compressed, dorsal and ventral profiles almost evenly convex, covered with cycloid scales much smaller above lateral line, smallest along base of dorsal, top of head, caudal peduncle, base of anal, and on breast. On nape they extend forward to vertical of anterior margin of eye. In angle behind pectoral, there is a cluster of seven rather large free scales, and a similar cluster of about five smaller ones depending exteriorly from the last rays of the fin. A long pointed scale present on side above base of ventral, and a similar one behind fin attached to last ray. Lateral line commencing at upper angle of operculum curves upward with a short bend to below first ray of dorsal, thence fairly straight to vertical of fifteenth ray; it then bends downward rather steeply for a short distance, thence follows a moderately straight course to peduncle. Before pectoral the lateral line is very distinct, getting gradually less distinct behind, while on peduncle it is almost lost.

Head with scales on cheeks, posterior margin of interorbital, maxillary, operculum and interoperculum similar to those on body, but smaller. The broad margin of the preoperculum is scaleless, but showing striae. Whole of snout and lower jaw naked. Profile of head very blunt, lower jaw a little the longer when mouth is shut; it appears very much longer with the mouth open. Two nostrils in about a middle line with eye, the posterior oblong, anterior larger, rounded. Upper jaw with an outer series of acute subulate teeth and an inner series of smaller ones. In lower jaw the outer series is the smaller, the inner ones being similar to outer series in upper jaw. Small acute teeth present on vomer, and palatine bones, the latter being very well furnished, tongue smooth. Gills, 3½; gill-rakers 12, on lower half of anterior limb, the latter having as many as 28 teeth on inner margins. Pseudobranchiae present. The second ray of dorsal highest, those folowing, as far as eleventh, decreasing somewhat rapidly in height: thence they become fairly uniform to the last. Narrow transverse scales present on all spines and rays and interradial membranes, their margins free. Anal similar to dorsal but much lower. Pectoral long, reaching backward to eighteenth ray of dorsal. Ventrals small with a short strong spine. Caudal deeply forked, lobes about equal, its rays covered with scales similar to dorsal and anal fins.

Colour: Above lateral line dull bluish-silver, below the colour was dull silver with a darker brownish-silver patch about middle of body; most of the scales have an inner crescentic blackish band. Dorsal fin dull bluish-black, the scales somewhat lighter. Anal similar but paler. Caudal same as dorsal. Ventral and pectoral clear bluish-horn. Eye golden and blue-black, with an outer ring of bluish-white margined with dark brown.

Described and figured from a fine specimen which is 526 mm. long from the premaxillary symphsis to the caudal peduncle. The head is 147 mm., eye 37 mm, greatest height of body 240 mm., caudal peduncle 30 mm.

Identity and synonymy: The species here described is the first of its kind received at the Auckland Museum. It was taken in the trawl by Capt. Holt of Sandford's, Ltd., to whom I am indebted for saving the fish for the Museum collection.

Although there is some variation noted by different observers, my specimen agrees so well in all essential points that I have no doubt as to its correct identity. There is little doubt that *Toxotes squamosus* Hutton* should be regarded as synonymous; unfortunately Hutton's specimen appears to be lost, so that a comparison is out of the question. According to McCulloch, Ray's Bream appears to be rare in Australian waters, but McCoy records it at Portland, Victoria, in considerable numbers in April 1884. In New Zealand, Phillipps records it from Napier, Queen Charlotte Sound, and Plimmerton. Clarke's figure given by Phillipps in the *N.Z. Journ. Sci. and Technology* was drawn from a specimen taken at Hokitika in 1872. The fish, however, has a very wide geographical range; Guenther states, it is found on the English coasts, Meditterrean, and Cape seas.†

Locality: Trawled between Te Kaha and White Island, Jan. 1928. Specimen in the Auckland Museum.

Family PEMPHERIDAE.
Genus PEMPHERIS, Cuvier.

KEY TO THE NEW ZEALAND SPECIES.

Eye 7½-8 in the length from the premaxillary symphysis to the end of the middle caudal rays.
No mesial line of cycloid scales from interorbital to origin of dorsal. Ventrals cover the vent ... *compressa.*
Eye smaller, rather less than 9 in the length from the premaxillary symphysis to end of middle caudal rays.
A narrow mesial line of cycloid scales from interorbital to origin of dorsal. Ventral smaller, reaching to anterior margin of vent ... *adspersus.*

Pempheris compressa, Bullseye. (Fig. 5).

Sparus compressus, Shaw, *White's Voy. N.S. Wales*, 1790, pl. 12.
Pempheris compressus, Stead, *Ed. Fish. N.S. Wales*, 1908, p. 49. pl. 18.

Br. 7; D./vi/XI; A.iii/XXXI; P.i/XV; V.i/V; C.xvi/2/2. L. lat about 74; L.tr, 12/20.

Height of body, 2.4; head, 3.5¾ in the length from the premaxillary symphysis to end of middle caudal rays. Eye nearly 8 in the same or rather more than 2 in the head, and about 3 in the height of body. Maxillary about 2½ in the eye. Caudal peduncle ¾ the eye.

Body deep, short, highly compressed, dorsal profile rising moderately from tip of snout to dorsal fin where it is highest, from thence a slight slope to caudal. Ventral surface much straighter. Whole of body and head covered with small ctenoid scales which extend forward on interorbital nearly as far as anterior margin of eye. Similar but smaller ctenoid scales are present crowded on the

---

**Trans. N.Z. Inst.*, vol. 8, 1876, p. 210.
†Guenther, *Brit. Mus. Cat. Fish.* vol. 2, p. 408.

cheeks, opercles, preorbital, maxillary, and lower jaw; the tip of snout only is scaleless.

Lateral line forms a very even curve, and extends almost to end of middle caudal rays. From anterior portion of lateral line there is a branched line extending over top of operculum, ending above middle of top of eye, and a similar curved one over shoulder uniting with branched line above eye. A few small slightly-hooked spines present on lower angle of cheek, also a single but larger double-toothed one exactly at angle. Operculum without spines or excavations. A small bony point on upper anterior margin of preorbital. Maxillary extends backward to vertical of three-fourths of orbit. Teeth in both jaws in a single series, those in the upper somewhat scattered with a very few longer ones between. Teeth in lower jaw smaller and more uniform. A broad triangular band of teeth on vomer, and a narrow band on palatine bones. Tongue smooth.

Gills, 4; gill-rakers long, 23 on lower half of anterior limb. Dorsal fin rises almost in the centre of back, its origin slightly nearer tip of snout than to procurrent caudal rays. The anal originates in vertical of the 6-7th dorsal rays. Pectoral pointed, reaching beyond last dorsal ray when laid back. The ventrals cover vent, but do not quite reach first anal spine.

Colour: Above lateral line light brownish-silver with darker clouding. Below lateral line uniform light brownish-silver. A few minute reddish-brown dots are scattered about on sides of body; I counted not more than 16 above the lateral line, and about 80 below. Head similar in colour to body. Dorsal fin with its first six spines pale reddish-brown at base, but the tips of the three first rays are much darker. Caudal lobes and anal fin tipped with reddish-brown similar to dorsal. Pectoral and ventral uniform cream-white.

Affinities: At first sight this fish appears very like *P. adspersus**, but a critical examination discloses some differences between the two species which are well explained by the key provided at the head of this description.

Described and figured from a fine specimen which is 120 mm. long from the symphysis of the lower jaw to the caudal peduncle. Greatest height of body, 52 mm.; head, 41 mm.; eye, 19 mm.

Locality: Kawau Island, Hauraki Gulf, Auckland, February, 1928. Specimen in the Auckland Museum.

Family LATRIDIDAE.
Genus LATRIS, Richardson.

Latris lineata, Trumpeter. (Fig. 6).

Cichla lineata Bloch. & Schneider, *Syst. Ichth.*, 1801, p. 342.

Latris hecateia Richardson, *Trans. Zool. Soc.* 3, 1842, p. 106, pl. 6, 1.

Latris hecateia Rich. Hutton, *Cat., Fish. N. Zealand,* 1872, p. 8, pl. 2, Fig. 12.

Br. 6; D.xviii/I/XXXV., A.iii/I/XXVII., P.XVIII., V.i/V., C.xv/3/3.

More than one hundred scales in the lateral line, the transverse series being about seventeen above, twenty-nine below. Head, 3.7¾,

**Pempheris adspersus*, Griffin. *Trans. N.Z. Inst.*, vol. 58, 1927, p. 139.

depth 3.5½ in the length to the base of the middle caudal rays. Eye rather more than 5 in the head or two in the snout, and about 1¼ in the interorbital space, the latter being subequal with the caudal peduncle.

Body compressed, oblong, dorsal and ventral profiles equally curved, covered with moderate cycloid scales. Small cycloid scales also found on top of head, extending forward as far as posterior nostril, also on cheeks and operculum, but margins of preoperculum and interoperculum are only partially scaled. The whole of the snout, lips, maxillary and lower jaw are scaleless.

Lateral line rather high, nearer dorsal than middle of fish. It is very little curved, oblique on peduncle.

Top of head slopes steeply to symphysis, but there is a slight convexity in middle. Eye large, placed nearly in middle of the length of head, nearer upper profile than lower. Two nostrils, the posterior a round foramen, the anterior somewhat oblong, provided with a strong cutaneous flap on posterior margin. The maxillary does not reach anterior margin of eye, and at least half its width is hidden beneath the preorbital. Lips tumid, upper jaw longer than lower. Villiform teeth in both jaws, with an outer series of longer and stronger ones. Very fine teeth present on vomer, none on palatine bones or tongue. Angle of preoperculum broadly rounded. Operculum terminating in a flat point surrounded with skin. Gills 4, gill-rakers 17 on lower half of anterior limb. Pseudobranchiae present. First dorsal high, standing in a groove, the spines getting rapidly higher to the seventh which is highest, four and half times as high as the first, and rather more than 1½ times width of eye. From the seventh, the spines decrease in height very gradually, the last being about equal to the second, and separated from the seventeenth by low membrane. The first ray is simple, about three-quarters the length of the second which is highest, all the others decreasing very gradually in height backwards. The anal is similar to the second dorsal in every way, and both fins are contained in a narrow scaled sheath. Ventrals with a slender spine, length of which is subequal with fifth dorsal. Their origin is the vertical of middle of pectoral. Pectoral with upper and lower rays shortest; it reaches backwards to the vertical of the thirteenth-fourteenth dorsal spines. Caudal forked.

Colour: Dorsal surface and sides yellowish-bronze, with three whitish longitudinal bands, one near top of dorsal which becomes somewhat paler below the rays, another encompassing the whole of lateral line, while the third is in line with top of pectoral. Beneath this, the sides are blotched with light and dark yellowish-bronze. Ventral surface dirty yellowish-white. Whole of head similar to body-colour, but without bands. All fins bright greenish-yellow, streaked or blotched with thin blackish.

Described and figured from a specimen which is 515 mm. long, from the tip of snout to the hypural joint. The head is 147 mm. Eye, 29 mm. Caudal peduncle, 36 mm.

Locality and distribution: Mayor Island, in the Bay of Plenty, Auckland Provincial District. Taken on hand line by Mr. Shirley in December 1927.

This fish does not appear to be so plentiful in our warmer northern waters as it is in the south of New Zealand. Waite mentions that it was but once taken in the trawl of the "Nora Niven," a single specimen being obtained east of Lyttelton in 44-46 fathoms, while another example was caught at the Chatham Islands on a long line.*

Hutton, in his notes on the edible fishes of New Zealand, referred to at the head of this description, gives a very full account. He states that this species is very local in its habits, the areas which they frequent being very limited. It is found in one or two spots on the west coast of Otago, while the Kaikoura Peninsula appears to be a favourite haunt, about three miles off Point Keene; but that they may be taken off almost every point in the peninsula where the water exceeds sixteen fathoms.

I have seen this fine fish taken on the hand-line at Castle Point on the east coast, not a great distance from Wellington. It is probably much more plentiful in Tasmanian seas, to which it was supposed to be peculiar. It is also recorded from the banks near the Victorian coast, from whence supplies are taken to the Melbourne market. McCulloch states that it is said to occur in the southern waters of New South Wales, but is not reliably recorded.

Family SCOMBRIDAE.
Genus SCOMBER Linn.

Scomber australasicus, Mackerel. (Fig. 7).

Scomber scombus, Solander in Linné, *Syst. Nat.* 10th Ed., 1758, p. 297.

Scomber australasicus, Id Cuvier & Valenciennes, *Hist. Nat. Poiss.* 8, 1831, p. 49. Id Hutton, *Cat. Fish. N. Zealand*, p. 21, pl. 5, Fig. 32.

Scomber colias Stead. *Ed. Fish. N.S. Wales*, 1908, p. 94, pl. 63. Id McCulloch *Check list. Fish. N.S. Wales*, pt. 3, 1922, p. 104, pl. 33, Fig. 286a.

Br. 6; D.xi/I/XI/5; A.i/I/XI/5; V.i/V; P.XXII; C.XVI/5/5. Line lat, Ca 160; L.tr. Ca 20 above, 33 below.

Height of body, 4.5¾; head, 4.14½ in the length to hypural joint. Eye 4.10 in the head or nearly 1¾ in snout, and subequal with the interorbital space. Caudal peduncle width, 6 in the head. Adipose eye-lid 0.7 in head, or 2.4 in the snout. Body rather elongate, rounded, the dorsal and ventral profiles evenly curved, covered with small cycloid scales. A few scales are found on lower margin of cheeks, and on upper half of operculum, but the rest of head is scaleless.

Interorbital space almost flat. Preorbital extends as far as centre of eye, and maxillary as far as anterior border of orbit; it can be completely hidden beneath preorbital. Eye large, completely covered with thick transparent skin, which extends as far as posterior margin of cheek. Snout pointed. A single nostril situated about midway between anterior margin of orbit tip of snout. Lower jaw

*Waite, *Rec. Cant. Mus.*, vol. 1, No. 3, p. 219.

slightly the longer. Minute teeth in a single series in both jaws. Very minute teeth present on vomer and palatine bones, tongue smooth. Gills, 4; gill-rakers long, 27 on the lower half of the anterior limb. Pseudobranchiae well developed. First dorsal fin in a shallow groove, its origin slightly posterior to middle of pectoral, second spine longest, equal to distance from posterior margin of operculum to centre of eye, and subequal with base of dorsal rays. Second dorsal separated from first by interspace equal to three of the eye, its origin the vertical of vent. The fin is low, only half the height of longest spine, and followed by five spurious finlets. Origin of the anal is the vertical of third dorsal ray. It is similar to the second dorsal in every way, with five spurious finlets behind originating in vertical of dorsal finlets. Ventrals thoracic, their origin below first quarter of pectoral. Caudal forked, lobes subequal, with two low keels at base of procurrent rays.

Colour: Above lateral line bright bluish-green silver with darker oblique bars, most of which form a chevron pattern, except above pectoral where they are more rounded. Below lateral line, bright silver with a golden hue, covered with numerous irregularly-formed diffused spots and bars. First dorsal clear greenish-blue, second dorsal dusky greenish-blue, finlets somewhat darker. Anal fin, finlets, and ventrals white. Pectoral, thin bluish at base and on outer margin, lighter in the middle. Caudal same as second dorsal. Top of head, deep blue with darker bars. Preorbital, lower jaw, lower half of operculum and preoperculum bright silver with a golden hue; there is also a dark blue patch on upper posterior margin of operculum. Maxillary, dark brown.

Described and figured from a specimen which is 343 mm. long, from symphysis of the lower jaw to hypural joint. The head is 80 mm. long, eye 21 mm., greatest depth 70 mm.

Locality and Distribution: Auckland Harbour, December, 1927. Said to be very common in deep water beyond the Hauraki Gulf, moving along the coast in large shoals. Also common in Australian seas. Average length 14-15 inches.

Family GOBIESOCIDAE (Cling-Fishes).
Genus DIPLOCREPIS.

KEY TO THE NEW ZEALAND SPECIES.

a. Anal fin small, composed of 4 rays only. Snout pointed, interorbital space equal to diameter of the eye. Anus close to posterior margin of disk ... *puniceus.*

aa. Anal fin larger, composed of 7 rays. Snout broad, interorbital space equal to nearly 3 of the eye. Anus far behind the disk *tumidus* n. sp.

Diplocrepis puniceus (*Lepidogaster*) Richardson. *Ichth Erebus and Terror. Fish,* p. 71, pl. 43; Figs. 1-7.

Diplocrepis puniceus Guenther. *B.M. Cat. Fish,* 3; 1861, p. 506. Id. Hutton *Cat. Fish N. Zeal.,* 1872, p. 40.

(Fig. 8).

D.X., A.IV., V.I/IV., P.XXIII., C.XI. Gills 3, gill-rakers minute, 5 on lower half of the anterior limb. Gill membrane united under throat, free from isthmus. Pseudobranchiae rudimentary.

Height of body nearly 4 in length to hypural joint, head 2.5 or rather more in same. Eye 6 in the head or 1 in snout, and subequal with interorbital space. Breadth of head 1.9½ in the height of body.

Body moderately broad anteriorly and depressed, covered with tough skin, dorsal profile with a long even curve from tip of snout to caudal. Upper surface of head and nape convex. Snout convex mesially. Two nostrils in low tubes, close together, opposite angle of orbit, anterior one provided with a very short tentacle on posterior margin. Eye rather large, slightly cutting profile. Mouth horizontal, narrow, angle reaching back a little beyond anterior border of eye. Lips not greatly thickened, lateral portion of lower lip hanging downwards. Upper jaw with ten-eleven, lower with eight or nine small incisors, lateral teeth being conical. A band of minute cardiform teeth present behind outer series in both jaws. Operculum with a deep excavation on posterior border, and an acute spine at angle. Origin of dorsal fin a little posterior to vertical from vent. Anal fin small with origin below eight-ninth rays of dorsal. Caudal of moderate length, rounded. Pectoral broad, rounded on posterior margin; there is a thick fold on the lower part of base which ascends beyond middle of fin. The adhesive apparatus is broad, posterior portion of disk overlapping sides of fish. In several individuals examined, I find some variation in both the adult and young forms in the pattern of the disk; the drawing of this intricate organ is from a typical example.

Colour: Beautiful uniform rose-red with darker red dots and marblings on sides, forming rather broad bands over the dorsal. All fins similar to body-colour, but in some specimens, I have seen all the fins heavily tipped with dark purple-brown.

Described and figured from a fine specimen which is 66 mm. long from tip of snout to hypural joint. The head is 26 mm. long, its greatest breadth, 29 mm.

Locality: Ponui Island, Auckland Harbour, common.

Diplocrepis tumidus, n. sp. (Fig. 9).

Br. 4; D.VIII., A.VII., V.i/IV., P.XXII., C.XII 2/2.

Gills 3, gill-rakers 3, very short and broad on the lower half of the anterior limb. Gill-membrane united under throat, free from isthmus. Pseudobranchiae rudimentary.

Greatest height of body 4, head 2.7 in the length to the hypural joint. Eye 7 in the head, and nearly 3 in interorbital space. Breadth of head rather more than 2.4 in the length to the hypural. Body broad and depressed anteriorly, flattened on sides of caudal peduncle, covered with very tough skin. The dorsal profile rises steeply from tip of snout to above centre of pectoral, thence slopes gently to caudal. The ventral surface is moderately straight, vent situated a little beyond middle distance from posterior margin of disk to anterior ray of anal. A small genital papilla behind the anus well exposed. Head depressed, not quite so broad as long. Top of snout broad, very little convex. Eye near profile, but not cutting it. Two nostrils on snout, posterior above centre of eye about a quarter of eye's breadth away from orbit, anterior nostril close to and in

front of former, tube short, with club-shaped tentacle on posterior margin, length of tentacle subequal to posterior nasal tube. Mouth oblique, large, obtuse, jaws subequal. Lips tumid, narrowed at symphysis, expanded laterally, those on upper jaw directed upwards, those of lower jaw downwards. Angle of jaw extends back to a little beyond centre of eye, while maxillary reaches vertical from centre of orbit. In upper jaw there is an outer series of small uneven recurved canines, about seventeen in front, fewer and smaller canines are found in lower jaw, while there is a broad band of small cardiform teeth behind outer series in both jaws, crowded in front narrowing on sides. Posterior margin of opercular apparatus fleshy, overlapping base of pectoral. A small spine entirely hidden in skin at lower angle of cheek.

The dorsal fin originates a little distance behind vertical from vent, ending near procurrent caudal rays. The anal origin is below third ray of dorsal to which it is similar. Pectoral broad, rounded, reaching backward as far as posterior margin of disk; it is connected to ventral by a thin membrane. Anterior portion of adhesive disk, between ventrals is broader than long. Posterior portion forms a complete disk by itself, is as broad as long, not counting marginal fringe. The latter is composed of very delicate cutaneous membrane, while the hardened epidermis within both portions of disk forms a beautiful mosiac of various-sized polyogonal plates. · Similar lamellae cover under surface of ventral fins.

Colour: By comparison with "Ridgway's colour standards," I find the general ground-colour of this handsome little fish a uniform pansy-purple No. 16, pl. 12, in the work quoted. The darker stripes very distinct blackish-purple No. 8 of the same plate. Ventrals white, all other fins the same colour as ground-colour of body.

Described and figured from the holotype which is 77 mm. long from tip of the snout to hypural joint, length of head is 31 mm.

Identity and variation: At first sight it looked as if this fish would turn out to be identical with *D. costatus*, an Australian species described by Ogilby in the *Pro. Linn. Soc. N.S. Wales*, vol. 10, 1885, p. 270; but the fact that in Ogilby's fish, the snout is pointed and the eye equal to the interorbital, definitely determines it not to be this species. Altogether I have 8 examples ranging from 45 mm. to 80 mm. in length, and on comparing the holotype with the paratypes, I find some variation in colour only. In some, the stripes are not nearly so distinct or broad, especially is this the case with the smallest specimen, while there is one of 58 mm. in length which has a very light-coloured lateral stripe on either side, commencing behind the eye, passing over the upper portion of the operculum, then behind the top margin of the pectoral, gradually ascending towards the dorsal fin, where it ends abruptly below the last ray. The stripe is considerably lighter than the ground-colour of the fish, almost as broad as the eye as far as the posterior margin of the pectoral, from thence getting much finer towards the caudal.

Locality: Ponui Island, Auckland Harbour. Obtained in rock-pools, fairly common. Holotype and paratypes in the Auckland Museum.

Family ANTENNARIDAE.
Genus ANTENNARIUS Cuvier, Reg. Anim. Ist. ed., ii, 1817, p. 310 (*chironectes*).

Antennarius striatus, Striped Angler. (Fig. 10).

Lophius striatus Shaw, *Nat. Miscel.* 5, 1794, pl. 175.
Antennarius pinniceps Cuv et Val. Guenther. *Brit. Mus. Cat. Fish.* 3, 1861, p. 190.
Antennarius striatus Guenther. *Fisch Sudsee* 5, 1876, p. 162, pl. 99.
Antennarius striatus McCulloch, *Check List, Fish and Fish-like Anim., N.S.Wales,* pt. 3, 1922, p. 123, pl. 12, Fig. 357a.

D.iii/XII., A.vii., P.X., V.v., C.ix.

Height 2.14, head, 3.39 in the length to the hypural joint. Eye, 7 in the head or 3 in the snout. Head, with swollen cheeks and a deep depression below the eye. A deep pit on the occiput, perfectly smooth inside, receives the distal ends of the two anterior dorsal spines. Tip of snout produced into a bulb-like depressable process, first and second dorsal spines being attached to this.

Mouth subvertical, maxillary the same. Lower jaw slightly longer than upper. Cardiform teeth in both jaws in a single series. Cardiform teeth also present on palatine bones and tongue. Nostrils small, subequal, lateral, placed close together, anterior almost on margin of premaxillary, both surrounded with a moderately high transparent rim. Gill-opening reduced to a small foramen situated behind pectoral, rather nearer angle than end of fin. Gills 4, no cleft behind the fourth. One half only of anterior arcus branchialis provided with lamellae, and no gill-rakers present on this limb. Pseudobranchiae none.

Body robust anteriorly, compressed towards caudal, covered with rough skin containing numerous minute trifid spines which form into clusters on maxillary, front of lower jaw, above eye, and extending over body in the form of a lateral line ending above the centre of anal fin. A few longer cutaneous branched fillaments depend from margin and centre of lower jaw. Stomach wide; pyloric appendages none; air-bladder present.

Anterior dorsal spine slightly longer than the second, very delicate, terminating in three lanceolate flaps with minute doubly crenulated margins. Second and third spines of dorsal furnished with clusters of minute spinules at tips. All spines in fourth dorsal are subequal, reaching base of caudal when laid back.

Anal origin below sixth spine of the fourth dorsal, very similar to the latter in form and structure.

Pectoral long, arm-like, owing to the protraction of carpal bones. Ventral jugular short, extremity being similar to pectoral.

Colour: Light greyish-brown irregularly streaked with dark-brown bars of various shapes and sizes. Numerous streaks of dark-brown radiate over sides of head from eye. A series of oblong and rounded spots on cheeks, ventrals, and pectorals, also on under-surface.

Identity and variation: This fish agrees very well with the description of *A. pinniceps* quoted at the head of this paper, and which McCulloch regards as merely a colour-variation of *A. striatus*. The genus, according to Guenther, is subject to very great variation, scarcely two specimens of a kind being found exactly alike, consequently there is not another genus of fishes which offers so much difficulty in the determination of the various species.

Described and figured from a specimen 83 mm. long from tip of snout to hypural joint.

Locality and distribution: The specimen here described, when first seen was hiding in a bunch of seaweed, at Opua, Bay of Islands, Auckland Provincial District. It was later captured in a net by Mr. G. Cross to whom I am indebted for sending the fish to the museum, this being the first time the genus has been recognized from our waters. It is also recorded from New South Wales, the Ile de France, and the Indian Ocean. Guenther states that most of the species of this genus appear to be inhabitants of tropical seas, living on floating seaweed, and enabled by filling the spacious stomach with air to sustain themselves on the surface of the water. They are therefore found in the open sea, as well as near the coasts, and being poor swimmers are driven with the currents into which they happen to drift. Thus it is a natural consequence that at least some of the species should have a very wide geographical range.

Radium Emanation and Goitre.

By R. R. D. MILLIGAN and N. M. ROGERS.

[*Read before the Canterbury Philosophical Institute, 2nd November, 1927; received by Editor, 18th April, 1928; issued separately, 30th August, 1928.*]

IN 1925 Rogers (1) estimated the amount of Radium emanation in several drinking-waters of this district, with a view to determining if any correlation exists between the percentage incidence of goitre and the amount of emanation in the water of the localities under observation.

With the exception of Timaru a fair correlation was established, but definite conclusions could not be drawn. Many workers in different parts of the world have sought for a positive causative agent of goitre; for example, McCarrison is convinced that toxins produced in the intestinal tract by bacterial action play a definite role.

At the present time, however, a deficient intake of iodine and a resultant deficiency of the thyroid hormone (an iodine-containing compound) is the only cause established beyond doubt.

That a positive agent might tip the balance and transform a low intake into a pathological deficiency in the organs and tissues where it is required is plausible enough. Such agent might be the intestinal bacteria of McCarrison, or an unusual salt balance in the dietary producing excessive excretion either of the iodine or of the thyroid-iodine compounds. Again, Radium emanation which abounds in the artesian waters of this district, might by irritation of the thyroid render it unable to manufacture sufficient of the necessary compounds for the efficient working of the body.

In 1926 Milligan (2) reported that the administration of large amounts of emanation once a week to rabbits for the space of three months failed to produce any sign of thyroid disturbances as tested by microscopic sections of the gland. In his experiments the emanation was in some rabbits given by mouth and in others by injection into an ear vein.

Some of the observations now reported offer a criticism of the technique used in the rabbit experiments, although our conclusions agree that emanation does not appear to be a causative agent either for rabbits or for trout.

Trout were chosen for the present experiment because they are liable to contract a typical hyperplastic goitre and because they can be kept in a solution containing emanation for the whole period of the experiment.

In the grounds of North Canterbury Acclimitisation Society at Christchurch approximately one per cent. of the trout in their third year of life suffer from this goitre or so-called "gill cancer." Mr. Hope, the Curator, who has had a very long experience, states that he has never seen this condition in trout living in natural conditions.

Marine and Lenhart (3) in 1910 reported that the so-called "gill cancer" in the brook-trout of Pennyslvania (*Salvelinus fontinalis*)

was curable by the administration of iodine, and was not a true cancer of the thyroid but an epithelial overgrowth of the gland with none of the characteristic features of malignancy.

In Christchurch, the trout that have this condition are markedly undersized, thin, and sluggish in movements, but curiously, the goitrous brook-trout observed by Marine and Lenhart are stated to be larger than usual, and though excessively fat are "weak and lumbersome."

In Christchurch, as in Pennyslvania, the affected fish may live for a considerable time after the swelling has become prominent.

Marine and Lenhart speak of cases of spontaneous cure of goitre in brook-trout, but this does not appear to occur in the Christchurch ponds, at least after the goitre has become externally obvious.

The difference in behaviour of the goitrous fish is possibly accounted for by the fact that all the trout goitres seen here are hyperplastic and contain very little stainable colloid, whereas the illustrations given by Marine and Lenhart (3) show far more colloid than our specimens, and presumably they are typical sections.

Iodine Content.

Marine and Lenhart give no analysis of the glands.

The analyses of fish thryoids (normal) known to us, are given by Cameron in *The Biochemical Journal*, vol. 7, 1913.

The iodine in different species and genera of sea-fish is there stated to range from 0.2 gms. per cent. of dry gland to 1.10 gms. per cent. Eight of our own trout goitres, with an average dry weight of 1.4 gms. contained on the average 0.003 gms. per cent It is noteworthy that this amount of iodine is much less than we have found in human goitres (0.01 to 0.10 gm.%) and in normal human thyroids (0.04 to 0.05).

The iodine-content of even such a small number of trout goitres is probably typical.

In the absence of figures for normal trout thyroids our assumption may not be correct that the trout goitres contain approximately the same total amount of iodine as the normal thyroid, although this is true for human thyroids. Making these assumptions, however, rainbow trout would store about 0.040 mgms. of iodine per kilo as against 0.15 mgms. per kilo for man, i.e. approximately one-fourth of the latter.

Comparisons of this sort which lead to physiological considerations such as the relationship of thyroid-iodine to metabolic activity are well worth making, and it is to be regretted that our own data and other available records are so scanty and possibly, misleading.

Observations on Rainbow Trout.

These were begun on 27th October, 1926, at the local hatchery, indoors, using twenty-four one year old rainbow-trout. The hatching races permitted the same conditions to the controls and to the experimental fish. The entering water was well aerated by spraying, and the lower part of the race was ensured of aeration by means of a waterfall between the two sections.

A dozen trout of suitable age, i.e. two years old, were put in each of two parallel races. The rate of flow was 80 gallons per hour through troughs one foot wide and six inches deep. The fish were fed by the Curator on raw beef liver and lung—the usual diet.

Although this question of a suitable dietary is of importance (for example a deficient supply of vitamines might be involved or an unusual salt balance) our attention was solely directed to investigating the effect of emanation on the trout.

Approximately 20 millicuries of emanation were added each day to the water at the top of the race by dissolving the emanation in a large vessel of water from which a tube delivered the dissolved emanation drop by drop directly into the race without contact with the air. Care was taken to reduce loss of emanation to a minimum but as the tube delivered the emanation during the whole of the time the quantity added fell off towards the end of the period, partly through decay and partly through loss into the air of the vessel.

This method of giving the emanation was followed in all the experiments with trout.

While emanation was freshly added each day as a rule, on Sundays this was not done.

Even over the week-ends, however, emanation was being delivered from the vessel.

The trout were all rainbow-trout, as these, according to the Curator, are more liable to goitre than the brown trout. Whether this is due to the fact that brown trout stay closer to the bottom than the rainbow and so get some dietary constituent that the surface fish do not get, or whether the reason depends on the genetic constitution of the fish, we have no means of deciding.

No goitre appeared, but several deaths occurred, due to the trout being very restless and biting at each other's tails.

The tail-fins in some instances entirely disappeared and because of this at the end of two months only twelve of the original trout remained.

Whenever a death occurred another fish was added to the race.

Tail-biting was as prevalent in the control race as in the one to which emanation was being added.

The water of the two races was tested for emanation on several occasions.

The following figures are typical:—

30th October, 1926	120×10^{-12} mc.
11th November, 1926	126×10^{-12} mc.

Control tests of the water in the other races showed a quantity of 1.5×10^{-12} so that the test trout were getting about eighty times as much as the controls.

On 3rd December, 1926, because of the tail-biting, the trout were removed to an outside race which appeared to be particularly suitable. This race was flask-shaped. In the bulbed end, which was really a hole formed in the earth and shingle by the artesian inflow, and which was without flooring, about twenty trout had been kept for some years. In one of these a fish of about three pounds weight had a large goitre.

The neck of the flask was the part where we placed the trout which were to get the emanation. This was a wooden race 35 feet by 3 feet, and the water was 10 inches deep. The inflow was 30 litres per minute from the artesian bore. Between the neck and the bulb a grating was placed and the vessel discharging the emanation was was placed here.

The number of trout receiving the emanation was made up to thirty.

From this time on, no tail-biting occurred and no deaths.

They were fed exactly as before and thrived well.

On 19th March, 1927, a sample of water from the middle of the race gave 50×10^{-12} mc. per cc.

From time to time other tests were made, and they never showed quantities less than this.

On 11th/5/27 the trout were all removed and carefully examined No trace of goitre was observed. The Curator remarked that they were as healthy a lot as he had ever seen.

We decided to terminate the experiment, believing that we had given sufficient time—six and a half months—for the development of goitre if radium emanation were a potent cause.

We were also of the opinion that the number of trout used was sufficient and that a large number would only have confused the issue by introducing such factors as over-crowding, faecal contamination, shortage of food, and so on.

It seems clear that when such large amounts of emanation produced no visible effect in this time, the change of the small amounts occurring normally being a casual factor appears to be negligible.

A sideline on this experiment is that in a separate race we placed three trout suffering from goitre, and added crystals of Potassium Iodide, at frequent intervals.

After three months, however, all three were dead, the goitres apparently being as big as ever.

Diffusion of Emanation.

In Milligan's previous experiments emanation was given by the ear-vein route. It is desirable to know how much of the emanation is retained. To avoid loss of emanation a rabbit was anaesthetized with paraldehyde and placed in a large jar whose mouth was covered with a rubber sheet which was pierced by a hole through which the ear could be drawn.

The injection was made into an ear-vein and the jar immediately closed so that no escape of emanation could occur, either during the injection or afterwards.

The rabbit was kept in the vessel for 2½ minutes and a sample of the air was then taken in a gas sampler.

Compression of a rubber bulb maintained a constant circulation of air through the sampler and ensured the accuracy of the sample.

At 2½ minutes the sample was taken and the rabbit removed from the vessel. The vessel was filled with water and emptied several times.

At the end of of the next $2\frac{1}{2}$ minutes the rabbit was returned to the vessel and after a further $2\frac{1}{2}$ minutes a second sample was obtained. This was repeated several times.

Results of first $2\frac{1}{2}$-minutes—the gold leaf fell 1/10.5 divs. per cc. per second.

Second $2\frac{1}{2}$ minutes—gold leaf fell 1/276 divs. per cc. per second.

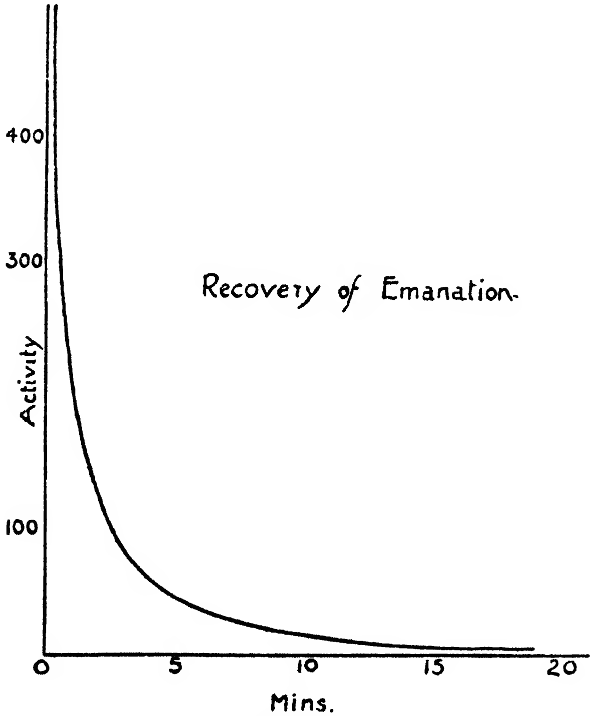
Third $2\frac{1}{2}$-minutes—gold leaf fell 1/720 divs per cc. per second.

Fourth $2\frac{1}{2}$ minutes—gold leaf fell 1/1800 divs. per cc. per second.

Fifth $2\frac{1}{2}$-minutes—gold leaf fell 1/4800 divs. per cc. per second.

It was calculated that approximately 95% of the emanation injected had been recovered in the first five minutes, and it was felt that the amount actually expired was even greater than this. The fact that the rabbit re-breathed some of the expired emanation and that in addition some emanation would be dissolved in the water held in the fur would tend to make the apparent excretion less that would be the case if the animal were in the open air.

The graph summarizes these facts.



These analyses are of interest as we have been unable to find any similar tests in the literature available.

Medical uses of radium emanation, both by injection and by the mouth-route, are fairly common, yet it does not appear to be recognized that any introduction of emanation into the venous side of the circulation must be almost without effect on the arterial side, or that

only a small fraction of the total effect will be produced, since the emanation is very rapidly given off at the lung-surface.

By a mouth-route, however, the liver would receive more, although the emanation will still go on by the blood and lymphatic streams to the lungs. This may have been a factor in the production of the fatty liver mentioned by Milligan as occurring in one of his experimental animals.

The volume of 20 mc. of emanation is only 0.012 cmm. This minute quantity should diffuse through the pulmonary epithelium in about 0.00008 seconds if it diffuses in a manner proportional to carbon dioxide, i.e., supposing there is no injurious effect on the living membrane.

It is obvious therefore that, with the evacuation of alveolar contents occurring with each expiration, only minute quantities of emanation can be expected to cross to the arterial side. Consequently it would be unreasonable to expect effects on the thyroid gland of animals from emanation taken in with food or water. Inhalation in a closed chamber is the most effective way of studying the effects of emanation on the thyroid gland.

The exceedingly delicate method of the electroscope, however, discloses that an appreciable quantity can pass through to the arterial side since in one test, thirty minutes after giving 20 mc. of emanation to a rabbit by ear-vein, the urine gave a fairly rapid fall of the gold leaf, although this indicated only an exceedingly small fraction of the total quantity injected.

While these observations offer a criticism of the venous route in mammals, the experiments on trout were free from this difficulty.

Not only did the trout inevitably take the emanation into their branchial arteries at the same time as the other gases but in addition the water containing the dissolved emanation was always close to the exterior of the gland as it flowed over the floor of the mouth.

Our thanks are due to the Curator, Mr. Hope, for placing facilities at our disposal.

REFERENCES.

(1) Rogers "Radon and Iodine content of waters." *Trans. N.Z. Institute*, vol. 57, pp. 893-99.

(*Note*: A line was dropped in setting this paper, and the present opportunity is taken of rectifying this. On p. 899, delete line 11 of the text, and substitute for it the words "contains iodine is a surprising result, but in view of the.")

(2) Milligan "Radium Emanation and Goitre." *Trans. N.Z. Institute*, vol. 58, pp. 283-85.

(3) Marine and Lenhart "The so-called Thyroid Carcinoma of Brook Trout." *J. Expt. Med.*, vol. 12, No. 3.

The Soil and Pasture in Relation to Pining and Bush Sickness in Sheep.

By R. E. R. GRIMMETT AND BEATRICE W. SIMPSON.
(from Department of Agriculture, New Zealand, and the Rowett Research Institute, Aberdeen.)

(Communicated by B. C. ASTON.)

THE account given by McGowan (1) of "pining" in sheep, a disease which occurs in certain areas particularly in the south of Scotland, shows that there are many points of similarity, both in the symptoms and in the general environmental conditions under which this disease is developed, with the disease of "bush sickness" as it occurs in New Zealand. The prediction was thus made by Aston (1924) that these two diseases may be of a similar nature (2).

As a result of a six months' transfer of one of us (R. E. R. Grimmett) from New Zealand to the Rowett Institute in 1927, under a grant from the Empire Marketing Board, an opportunity arose for the application of his experience of the soil and pasture conditions of "bush sickness" areas in New Zealand to a study of the related aspects of "pining" in Scotland. He accordingly spent some days in examining the field conditions in a "pining" area, and was fortunate in seeing "pining" sheep, some of which were recovering under treatment by administration of iron ammonium citrate. Samples of pasture were collected, with special precautions to avoid contamination by soil, and a large quantity of soil was obtained from one of the best known and most typical porphyrite "pining" hills. This was transferred to Aberdeen for use in pot experiments.

It has been shown by Aston (2) that the onset of "bush sickness" in sheep and cattle is due to the stock grazing upon pasture which has an abnormally low iron-content, although apparently not deficient in other respects and noted for its fattening qualities. The extreme anaemia which results may be cured by administering suitable iron compounds, such as iron ammonium citrate, or by removal of the stock to pastures rich in iron. The animals can then be returned to the former grazing and will thrive for a considerable period, before needing to be changed again.

Work by Aston and one of us (R. E. R. Grimmett) (2 and 3) has shown that " bush sickness" and iron-deficiency in New Zealand pastures are apparently to be associated with certain definite physiographic and soil-conditions, such as, a sandy soil with less than 5% of clay, resting on a pervious sub-stratum elevated considerably above the permanent water-table in a region, usually of fairly extensive level or undulating hill top, where the annual rainfall is high. Under such conditions, favourable to soil-aeration and leaching, the total amount of soluble iron in the soil at any one time is small, and it is only the pasture growing on the lower seepage areas which is rich in iron. The soil of the Patetere Plateau in the Roto-

rua District, a typical "bush sickness" area, is derived from rhyolite pumice, resting on a porous rhyolite tuff. Typical pasture and soil analysis from this area have been recorded by Aston (2). (Cf. Table 4).

In this connection it may be noted that McGowan (loc. cit.) in his description of typical "pining" country in Scotland, written at a time when he was unaware of the work on "bush sickness," might have been outlining many of the features of typical "bush-sick" country in New Zealand. Thus he states that waterhead farms are generally free from "pining," and, on the other hand, where only a small amount of green inflowland is present about stream sides, or an arrangement of the fencing prevents sheep grazing on this herbage, such conditions favour the disease. Further (unpublished personal communication), he had observed the anaemia and on the basis of other work had made arrangements for the administration of iron to the effected sheep. These tests fell through for the time being, but subsequently further opportunity arose (in the summer of 1927) and the shepherd in charge reported a beneficial result from the administration of iron ammonium citrate.

Following on the observations of McGowan on "pining" an investigation, the details of which have not as yet been published, has been progress at the Rowett Institute into the relative mineral-contents of pasture from "pining" and "non-pining" areas, and in general the results show that the iron content is lower in the "pining" than in the "non pining" herbage. Certain results also suggest some difference in the manganese content. In this connection, in sampling pasture in "pining" and in "non-pining" land it must be noted that the herbage of a "non-pining" area is not necessarily all "non-pining." The preventive condition may be due to the stock grazing for a portion of the time upon herbage growing on seepage areas or banks of streams in the main grazing, such herbage being relatively rich in iron. Such areas, being small, are liable to be overlooked in sampling, and thus faulty conclusions may be drawn from the analytical results. These areas should be sampled separately, in addition to taking samples from the main grazing, and any difference in composition should be borne in mind when considering differences between "pining" and "non-pining" pastures from the same locality.

When sampling pastures for iron and manganese analyses, special care must be taken to see that the herbage collected is free from soil or other contamination likely to affect the iron and manganese figures.

Strong evidence has been advanced by Dickenson (4) that King sand "coasty disease" is of the same nature as "bush sickness" and on that island the affected soil is largely composed of shell grit with up to 50% of calcium carbonate in the soil. This is of interest as it has been found that the application of lime to "bush sickness" pastures does not improve the pasture and materially increases the severity of the disease, presumably owing to the depressing action of the lime upon the solubility of the iron salts. (Cf. Gile (5) and Johnson (6).)

PRESENT INVESTIGATION.

The work outlined briefly below, while admittedly preliminary in character owing to the short space of time available, has brought out one or two points of interest. It has followed two main lines, namely (1) a series of pot experiments (2) a study of certain soils and pastures from "pining" and non-pining" areas and a comparison with cultivated pasture.

Pot Experiments.—This series of experiments, which formed the main line of work, was designed to test the effect of various chemicals when applied to the soil or culture medium, on the iron and manganese content of the crops. The main points tested were the effect of (a) lack of drainage (b) the application of organic matter (c) the application of iron in various combinations (d) the application of sulphur either in the free state or as ferrous sulphate (e) the application of lime, on the composition of the crops. These factors were chosen in view of the results obtained in the "bush sickness" investigation.

Five series of pots were set up: in three of which sand was the medium, in the fourth "pining" soil, and in the fifth arable soil was used. The sand was of granite origin from an Aberdeen pit. The nature of the "pining" soil will be referred to later. The arable soil was from a field in the Institute farm. Ordinary 11" flower pots were used and these were well coated on the inside with high melting point paraffin wax prior to filling, in order to prevent any contamination from the pot. Where drainage was not wanted the holes at the base were stopped up with corks soaked in wax. The arrangement of the pots in four of the series is shown in Tables 1-3, where the analytical data for the crops are given. The results of the other series are omitted owing to lack of growth. This was the series where 5% of humus mixture was incorporated with the sand, some of the pots being drained and some undrained. The pots in the series where sand was used were inoculated with two ounces of "pining" soil.

The experiment was started on August 14th, each pot being planted with 4 oat seedlings, 4 pairs of mustard seeds, 3 red clover seedlings and 3 cocksfoot seedlings, but only the oats and the mustard grew. The pots were out in the open until September 12th, when owing to inclement weather, they were taken into a room in the building. They were watered from time to time, as required, with distilled water, all the drained pots being treated alike in this respect. Growth having ceased by October 24th, the plants were cut ½" above the soil level, the oats and mustard being kept separate. The crop from each pot was weighed green; again after drying at 100°, and on the dry material, determinations were made of total ash, iron, and manganese. For the methods of analysis, see paper by Godden and Grimmett (7).

The analytical data for the different series are set out in Tables 1, 2, and 3.

TABLE 1.

Series "A." Each pot contained 24 lbs. of sand on top of 1 lb. of granite chips.

Treatment and Crop	Subseries (a) drained: Crop Wgt. Dry. Gms.	Percentages on Dry Matter: Ash	Fe.	Mn.	Subseries (b) undrained: Crop Wgt. Dry. Gms.	Percentages on Dry Matter: Ash	Fe	Mn.
1. Control. Oats ...	0.573	17.32	0.025	0.011	0.808	17.27	0.019	0.082
Mustard ...	0.504	20.30	0.028	0.011	0.187	19.85	0.027	0.033
2. Ferric Oxide, 2 cwt. per acre. Oats ...	0.729	18.52	0.019	0.009	0.709	17.37	0.020	0.072
Mustard ...	0.290	19.22	0.027	0.007	0.363	18.37	0.021	0.029
3. Ferric Oxide, 2 cwt. and sulphur 1 cwt. per acre Oats ...	0.601	21.53	0.017	0.027	0.725	18.28	0.025	0.091
Mustard ...	0.556	22.64	0.032	0.022	0.066	18.07	0.057	0.069
4. Ferrous Sulphate 1 cwt. per acre. Oats ...	0.706	16.20	0.020	0.019	0.749	18.78	0.023	0.092
Mustard ...	0.252	18.92	0.026	0.010	0.350	18.34	0.038	0.032
5. Ferrous Phosphate 1 cwt. per acre. Oats ...	0.676	18.14	0.021	0.012	0.628	18.15	0.023	0.078
Mustard ...	0.418	21.57	0.028	0.007	0.211	18.34	0.032	0.034
6. 5% of K "ball clay" and 1 cwt. Ferrous sulphate per acre. Oats ..	0.483	15.86	0.020	0.029				
Mustard ...	0.918	21.07	0.015	0.007				

The sand contained 1.14% Fe_2O_3 and 0.019% Mn_2O_3 soluble in concentrated hydrochloric acid and only a trace of each soluble in citric acid.

TABLE 2.

Series "D." Each pot contained 24 lbs. of "Pining" soil* on top of 1 lb. of "Pining" stones. The analytical data are for the oats only.

	Crop Wgt. (Dry) Grams.	Percentages of Dry Matter. Ash %	Fe. %	Mn. %
1. Control, undrained	0.100	13.84	0.025	0.280
2. Control, drained	0.188	15.97	0.017	0.181
3. Ferrous sulphate 1 cwt. per acre	0.175	16.02	0.022	0.169
4. Basic slag, 2½ cwts. per acre - - -	0.390	18.95	0.018	0.213
5. Ppd. Chalk, 5.2 tons per acre - - -	0.950	20.11	0.019	0.051
6. Sulphur, 2½ cwts. per acre - - -	0.191	15.69	0.020	0.170
7. Superphosphate, 2½ cwt. per acre -	0.372	19.47	0.021	0.195

*For analysis of this soil see Table.

TABLE 3.

Series "E." Each pot contained 24 lbs. arable soil* on top of 1 lb. granite chips.

	Crop Wgt (Dry) Grams.	Percentages on Dry Matter		
		Ash %	Fe %	Mn %
1. Control—				
Oats - - - -	0.224	17.87	0.020	0.013
Mustard - - -	0.529	20.00	0.043	0.006
2. Ppd. Chalk 3.1 tons per acre—				
Oats - - - -	0.194	16.93	0.032	0.007
Mustard - - -	0.764	22.13	0.038	0.005

A comparison of the results for the crops which grew show that, in most cases, the percentages of iron is higher in the mustard than in the oats, while the reverse is true for manganese.

In the sand-cultures (Table 1) the various chemicals applied appear to have had but little effect during the relatively short time of growth, except that sulphur, either free or as sulphate, has slightly raised the percentage of manganese in the crop.

Drainage conditions, during the relatively short period of growth, had no influence on the percentage of iron, but on the other hand had a marked effect on the manganese content of the plant. Thus the manganese content of the oats from the undrained pots (Series A, Table 1) is on the average about six times that of the oats from the drained pots. The difference in the mustard is slightly less. The water-logged and mildly reducing conditions appear to have had more effect on the manganese than on the iron, in rendering it available. This might be expected as the higher oxides of manganese are known to be more readily reduced than those of iron.

It will be noted that the addition of 5% of clay in pot 6 of this series had no definite effect on either the iron or the manganese content of the crop

The series grown on the "pining" soil (Series D, Table 2) offers the most interesting comparisons. On this soil the mustard seedlings failed to grow, possibly owing to their higher requirements of iron, and in the limed pot became markedly chlorotic prior to dying off. The iron content of the crop is throughout fairly uniform in all the pots. Again, however, the manganese is much higher in the oats grown in the undrained pot. The application of lime, on the other hand, has definitely depressed the percentage of manganese in the crop. Other manurial treatment appears to have been without effect in this direction. It should be noted that, while the percentage of iron in the crop from this series is approximately the same as that in the crop grown on sand, the percentage of manganese is more than ten times as high in the crop grown on "pining" soil, as that grown on sand. This high manganese content was apparently reflected during the ashing of the crop, the material burning with almost explosive violence.

*This soil gave:—Clay, 1.25%. Loss on ignition, 11.52%. Total, Fe_2O_3 3.05% Mn_2O_3 0.11%, and had a lime requirement equal to 0.31% $CaCo_3$.

The chief point in the case of the plants grown in the arable soil is the alteration in the iron-manganese ratio. Both the oats and the mustard grown on the arable soil have a higher percentage of iron than manganese, the reverse being true for the crops on the "pining" soil.

The percentages of iron and manganese in the sand, "pining" and arable soils, taken in conjunction with the percentages of these elements in the crop grown in these media suggest that the manganese is more easily taken up from the soil by the plant than is iron.

Soils and Pastures.—Samples of pasture from "pining" and "non-pining" areas in the same locality were collected with all precautions to avoid soil contamination, and the soil underlying the "pining" grazing was also sampled. A large sod was also cut out from the "pining" pasture. It was transferred to the Institute and divided into two portions. One half was planted in soil brought from the same area as the turf and the other half was planted in arable soil from the Institute farm. These cultures were made in wooden boxes. After removing the old growth they were left out in the open and from each turf two cuttings (the first on September 17th, and the second on October 6th) of the new growth were taken when the grass was about 2″-3″ high. The cuttings from each box were mixed and analysed. The results from the two samples were practically identical and it could hardly have been expected that the change in the underlying soil could produce any effect in so short a time. They serve, however, to show that the turf was uniform in character and these turves will be kept through the winter and during the next season will be cut regularly to imitate sheep-grazing and the material analyzed to determine whether changing the subsoil has had any influence on the iron and manganese content of the herbage.

The results of the mechanical and chemical analysis of the "pining" soil are given in Table 4 and for the purposes of comparison similar data for two samples of soil from "bush sickness" areas in New Zealand (Cf. Aston loc. cit.) are quoted.

TABLE 4.

Analysis of "Pining" and "Bush-sick" soils.

Mechanical Analysis.

	"Pining" Soil	"Bush-sick" Soil.	
	%	(S/181) %	(R/976) %
Fine Gravel	15.75	1.3	19.8
Coarse Sand	16.74	30.5	38.8
Fine Sand	15.82	27.4	14.9
Silt	18.16	18.6	8.4
Fine Silt	11.40	8.5	5.3
Clay	1.10	2.3	0.8
Moisture	8.94	1.6	1.0
Loss on Ignition	11.16	9.8	9.1
Matter Soluble in Dilute HCl.	0.96	—	—
	100.03	100.0	98.1
Stones and Gravel	31.3	4.5	13.6

TABLE 4 (Continued).

Chemical Analysis. (On soil dried at 100°).

	"Pining" Soil.	"Bush-sick" Soil.	
	%	(S/181) %	(R/976) %
Nitrogen	0.45	0.222	0.255
P_2O_5 (Total)	0.14	0.01	0.03
P_2O_5 (Available)	0.023	0.004	0.002
K_2O (Total)	0.45	0.07	0.08
K_2O (Available)	0.024	0.015	0.019
CaO Total	0.061	0.44	0.47
MgO Total	0.45	0.15	0.20
Fe_2O_3 (Total)	2.60	—	—
Fe_2O_3 (Cit. Sol.)	0.052	0.103	0.04
Mn_2O_3 (Total)	0.19	—	—
Mn_2O_3 (Cit. Sol.)	0.042	—	—
Lime Requirement	0.52% $CaCO_3$		—

The following additional figures from "bush-sick" soils are given for comparison.*

Mn_2O_4 (total) (L 1122)	0.43%
Mn_2O_3 (total) (L 1123)	0.39%
Mn_2O_3 (citric soluble) (Te Pu and Mamaku)	0.03—0.06%
Fe_2O_3 (total) (Te Pu and Mamaku)	1.00—1.39%
Lime Requirement (K 446)	0.37% $CaCO_3$
Lime Requirement (H 513)	0.38% $CaCO_3$

It will be seen that the Scottish "pining" soil and the New Zealand "bush-sick" soils have a very similar mechanical composition. They are sandy silts or of coarser texture, with a clay content of 2% or less. The "pining" soil is more amply supplied with available phosphate and potash, but has less lime, though more magnesia. The lime requirement of the "pining" soil is high (5.2 tons of $CaCO_3$ per acre) and this is indicated by the nature of the flora, which consists mostly of fine-leaved fescue but no clover. The citric soluble iron in both types of soil is low, although the iron soluble in hydrochloric acid is higher in the "pining" than in the "bush-sick" soil.

Table 5 shows the composition of the herbage from "pining" and "non pining" areas in the same locality and for comparison the figures are given for the herbage from a cultivated field at the Institute sampled at about the same date.

*See *Transactions New Zealand Institute*, vol. 44, p. 298. *New Zealand Journal of Agriculture*, vol. 17, p. 259, vol. 28, p. 387.

TABLE 5.

Pasture Samples. Percentages on Dry Matter.

	"Pining" Grass. Porphyrite Hill %	"Non-pining" Grass. Sandstone Hill.* %	R.R.I. Cultivated Grass. Laich Field. %
Dry Matter	100	100	100
Nitrogen	3.14	2.72	3.70
Total Ash	7.89	8.05	8.77
Acid Sol. Ash	6.79	6.63	7.26
CaO	0.32	0.56	1.12
Na_2O	0.03	0.04	0.48
K_2O	3 58	3.31	2.67
P_2O_5	0 91	0.66	0.89
Cl	0 63	0.79	0.79
Fe	0 013	0.014	0.025
Mn	0.106	0.049	0.016
So_3	1.01	1.13	0.94

The herbage from the "pining" pasture shows a similar iron content to that of this "non-pining" pasture, but has a much higher manganese content. The cultivated grass has a much higher iron and a much lower manganese content than either of the other samples. The manganese: iron ratio shows very considerable differences, being 8 : 1 in the "pining" grass, 3.5 : 1 in the "non-pining" grass, and 0.64 : 1 in the cultivated grass.

These results are borne out by a number of analyses previously made of other samples of grass from "pining" soil and "non-pining" areas in the south of Scotland, the figures for which were,

RANGE OF VARIATION.

	Iron Content	Manganese Content.	Mn: Fe Ratio
"Pining" Grass	0.005—0.013	0.038—0.064	7.6—3.9
"Non-pining" Grass	0.011—0.024	0.026—0.050	4.2—1.7

Whilst it may be suggested that the nature of the flora may have some influence on the iron content it is doubtful if this is the principal factor. Thus although the above "pining" herbage was of poor quality botanically and devoid of clover, the New Zealand "bush sickness" herbage was of good quality and contained abundance of clover, and yet both had a very poor iron content.

Whether the high manganese-iron ratio in the "pining" pasture has any significance or not, it is not yet possible to say. Very little is known at present as to the influence of a high manganese content or a high manganese-iron ratio of a diet on the health of stock. An investigation is, however, in progress at the Rowett Institute along these lines and will, it is hoped, throw further light on the subject. It may be a point of interest to note in passing, that, in the pot experiments, the application of lime, which on such highly acid soil as that in the "pining" areas might be expected to give a marked improvement in the herbage, resulted in a decided diminuition in the

*This "non-pining" area included some seepage and streamside pasture which was not separately sampled.

manganese content of the crop without affecting the iron content which was already at a low level.

SUMMARY.

The pot experiments recorded above are admittedly tentative and cover too short a growing period. It is hoped, however, to continue the work and obtain the results for mature plants. In the meantime it appears that on a given culture-medium lack of drainage is the most potent factor in increasing the manganese content and the manganese: iron ratio of the crop. Liming on the other hand tends to decrease both of these.

It would appear desirable to make a fuller survey of soils and pastures of the "pining" districts with a view to correlating soil texture and the physiographic features of the country with the iron and manganese content of the herbage and to make a further study of the effects of liming and of the application of iron-rich fertilizers.

We desire to acknowledge our indebtedness to Dr. J. B. Orr, Director of the Rowett Research Institute, and to Mr. W. Godden in whose department the work was carried out. for facilities granted, and for their interest taken and advice given in this investigation, and to Dr. J. P. McGowan for placing at our disposal his wide knowledge of "pining" disease.

REFERENCES.

(1.) McGOWAN, J. P. and SMITH, W. G. (1922). *Scottish Journal of Agriture*, *5*, 274.

(2.) ASTON, B. C. (1912) *Trans. N.Z. Inst.*, *44*, 288. (1924) *Trans. N.Z. Inst.*, *55*, 720. *N.Z. Journal of Science and Technology*, *1*, 216. *N.Z. Journal of Agriculture*, *28*, 215, 301, 381; *29*. 14, 84, 333, 369. (1925) *N.Z. Journal of Agriculture*, *30*, 1. (1926) *N.Z. Journal of Agriculture*, *32*, 365. *Trans. N.Z. Inst.*, *56*, 733. (1927), *N.Z. Journal of Agriculture* *35*, 96. *Trans. N.Z. Inst.*, *58*, 179, 536.

(3) GRIMMETT, R. E. R. (1927) *N.Z. Journal of Agriculture*, *34*, 289.

(4.) DICKENSON, C. G. (1927), *Australian Veterinary Journal*, *3*, 82.

(5.) GILE, P. L. (1920), *Journal of Agric. Research*, *20*, 33.

(6.) JOHNSON, *M. O.* (1924), *Hawaii Agric. Experim. Stn. Bull.* No. 52.

(7.) GODDEN, W. and GRIMMETT, R. E. R. (1928) *Journal. Agric. Science* (in press).

Since the above was written a considerable amount of fresh information concerning the calcium content of pastures and the effects upon the animal of a calcium-deficient diet has been gathered. In view of the very low calcium content of the "pining" pasture and the high lime requirement of the soil, it therefore seems possible that in this case the iron deficiency may be accompanied and the ill effect upon the animal aggravated by a deficiency of lime. The interesting possibility would thus arise of a simultaneous deficiency of mineral elements whose action under the peculiar soil conditions existing is such as to render them to a considerable extent mutually exclusive. This suggestion, which owing to considerations of distance, is made upon the responsibility of R. E. R. G. alone, is rendered more feasible by the fact that in areas adjoining those where "pining" exists, other workers have reported various obscure troubles in sheep, which are suspected of being due to some mineral deficiency. It will be noted that the herbage from the cultivated field has double the quantity of lime found in that from the "non pining" sandstone hill, which in turn has nearly double that found in the herbage from the "pining" porphyrite hill.

Occurrence of Manuka Manna.

By F. P. Worley, Professor of Chemistry, Auckland University College.

[*Read before the Auckland Institute, 4th October, 1927; received by Editor, 5th June, 1928; issued separately, 30th August, 1928.*]

Plate 66.

Manuka manna is a white, finely-crystalline, soluble substance occasionally found on *Leptospermum scoparium* in dry weather in the middle of summer. The cause of its occurrence has apparently not been investigated, nor has its chemical nature been fully determined. Preliminary examination of a small amount collected during the past few years has indicated that, like other mannas, it is a complex sugar. On hydrolysis, it yields only glucose. Further work on its composition is in process, but a larger amount of manna than at present available is required for complete investigation. The difficulty of obtaining the manna is due not only to its rare occurrence, but also to the fact that it is washed away by a slight shower of rain.

After spending considerable time looking for manuka manna without success, I was surprised to find in my own garden a young manuka (*L. scoparium* with double white blossoms) with many of the leaves in the middle and lower part of the shrub covered with manna. The mode of occurrence is shown in the accompanying figure.

No damage to the leaves could be detected, but on branches directly above the affected leaves numerous white plant-hoppers were observed, apparently feeding on the bark. Some of these were isolated and kept under observation until metamorphosis had occurred. The adult insect was identified by Mr. David Miller, Government Entomologist as *Scolypopa australis*. Neighbouring plants, including *Phormium tenax* and a large-leafed privet, were infested with the nymph and adult forms of *S. australis*, but no manna was present. The leaves of the privet and other shrubs were, however, covered with honey-dew, known to be produced by sap-sucking insects.

The following summer there was no occurrence of manna on the above manuka shrub, and no nymphs or adults of *S. australis* were observed, though they were abundant on neighbouring shrubs and produced a considerable amount of honey-dew.

Large areas of manuka on the Thames-Coromandel coast were examined, but the only occurrence of manna observed was on a very young tree in the grounds of a house I was renting at Thornton Bay. As in the previous occurrence, numerous nymphs of *S. australis* were observed on the branchlets above the deposits

Branchlet of manuka showing leaves covered with manna. Nat. size.

of manna. There appears to be little doubt that the manna was produced by *S. australis* in the nymph form.

The nymphs apparently require for their rapid development and metamorphosis only part of the constituents of the sap they consume, excreting or rejecting the greater part of the carbohydrate. In the case of manuka-sap diet, the excreted carbohydrate material crystallizes to a white solid, but when the food is derived from other trees, the carbohydrate remains on the leaves as a viscous covering of so-called honey-dew.

Manuka manna is sometimes formed in larger masses not distributed over the leaves, being due apparently to injury caused by a boring animal. It is possible that other sap-sucking insects besides *S. australis* may produce manuka manna, and it would be interesting to ascertain whether the manna produced by different insects has the same composition. It is also desirable to ascertain whether the honey-dew produced by the same insect on different trees differs in composition.

I should be glad of supplies of manuka manna and information of its mode of occurrence. I also wish to express my indebtedness to Mr. David Miller.

Mineral Content of Pastures.

Lime Deficiency in King Country Soils, and the Effect on Plant and Animal.

By B. C. Aston, F.N.Z. Inst.

[*Received by Editor, 30th July, 1928; issued separately, 31st August, 1928.*]

Iron-starvation ("bush-sickness") in ruminant stock occurs in its typical form when the animals are grazed on pasture grown on the coarse air-deposited rhyolitic pumice soils, particularly the sandy-silts and gravelly-sandy types, of the North Island volcanic plateau. Lying to the westward of this great area which may be measured by millions of acres, there are extensive areas of finer air-deposited soils belonging to the loamy types, derived from showers of mud or dust or similar fine-grained volcanic material which has been deposited on the soils derived from a limestone, rhyolite, or greywacke country rock which underlies them. This fine deposit weathers down to a fertile loam, and its section in the road cuttings presents a characteristic appearance—a brown loamy face which cracks up in summer appearing as a much fissured surface. This deposit is no doubt what Henderson and Ongley (1923) refer to in their *Bulletin of the Geological Survey* (No. 24 Geology of the Mokau Subdivision, p. 56) under the heading "Rhyolitic Rocks." The authors say: "Westward only the finest dust seems to have been "deposited. This has been to a great extent eroded and what remains "has been decomposed to a brown sandy loam of characteristic "appearance. Its distribution is not shown on the maps, but it "covers the hills and some of the valley bottoms over a wide area "and must at one time have covered the whole region. It may be "observed in the Mokau Valley west of Pio Pio, at many points on "the hills between the Mangaotaki and the Awakino rivers, and again "on the Taumataemaire Hill."

The area in which it is thought that a mineral-deficiency disease hitherto unrecognized occurs, is situated in the Mairoa and adjacent ridings of the Waitomo County. The situation of this area is generally about 1,000 ft. above sea-level, the rainfall being a heavy, well-distributed one.

In August 1926 the writer was first consulted regarding a type of soil occuring about 15 miles west of Te Kuiti. The first enquiry related to the soil itself which had ceased to produce the same good quality of sheep-pasture that in the past had given this district an excellent name as a fertile country in the years immediately following the "burn"—the operation of "bringing in" the bush-country, or in other words of quickly converting forest-land to a sheep and cattle-grazing pasture. It appeared upon investigation that land for which £17 an acre was refused previous to the war was now unsaleable even at one-third of that price, and that some farms had changed

hands at something like £2 an acre, a price which included dwelling and other buildings and all other improvements. Such rapid and great deterioration in the market-value could not be for the greater part attributed to falling prices.

The forest which originally covered this land was tawa (*Beilschmiedia Tawa*), rimu (*Dacrydium cupressinum*), rata (*Metrosideros robusta*), pukatea (*Laurelia novae-zealandiae*) while the undergrowth was fuchsia (*Fuchsia excorticata*), whiteywood (*Melicytus ramiflorus*), supplejack (*Rhipogonum scandens*), ribbonwood (*Hoheria*), fivefinger (*Nothopanax laetum* and *N. arboreum*), rewarewa (*Knightia*), mangeo (*Litsaea*), Freycinetia and similar shrubs; a type of primeval vegetation which usually indicates good soil rather than bad. The history of this settlement as given to the writer relates that for the first seven or eight years after the burn the pasture carried 1½ ewes to the acre and the lambs did well on it, but after this the pasture deteriorated very rapidly; the so-called English good grasses disappeared, and the carrying capacity fell below one dry sheep to the acre, and even with this diminished stocking the animals did not thrive. The extraordinary thing was that the usual remedy for deteriorated land, viz., top-dressing with phosphates, although it improved the summer carrying capacity did not effect the improvement hoped for in the returns.

The pasture on land that had been top-dressed with basic slag, superphosphate, and potash manures (8 cwt. in four years) was still apparently deficient in some ingredient. In summer the top-dressed pasture looked well and grew a lot of good grass, but in winter the ground became full of moss which disappeared in the summer. The number of culls in the flock was unusually high, although when these were taken to land where no deterioration had set in they fattened and often became the best sheep in their new home.

The topography generally is that of what would be called "easy country," and the whole is well watered by streams and creeks. A few samples of soil had been received and a composite sample made up for analysis showed that the soil was essentially a loam. Each sample (W 506-514) was tested for "lime-requirement" and gave results varying from 1.15 to 0.67 per cent. calcium carbonate required calculated on the water-free soil. Where, however, a sample (No. W508) was taken quite close to the limestone outcrops the "requirement" was only 0.4 per cent.

The chemical analysis of the composite soil W609 showed no deficiency of any of the three valuable ingredients of fertilisers, the available potash being very high, and phosphoric acid being high, while the total nitrogen was particularly high. The writer visited the locality for the first time in November 1926, and was struck with the poor condition of the sheep, which could not be explained by the lack of pasture. Some deficiency of the mineral food was suspected, especially as on examination the bones of sheep which had died were found to be uuusually fragile and light. An alternative theory held by some was that internal parasites were the cause of the poor condition. On obtaining the highest veterinary advice and on post mortem examination of sheep in September 1927 and subsequent dates it was found that the parasites present were not suffi-

ciently numerous to account for the condition, and the hypothesis of a deficiency-disease was adopted as the cause of the trouble.

The analysis of the soil not revealing any deficiency of nitrogen, available phosphoric acid, or potash, and the application of the two latter manurial ingredients to the soil failing to mitigate the deficency-disease, it was necessary to look for the deficient element or elements among those which are in normal soils present in quantity sufficient for the growth of plants and which are not generally required to be provided for plant-food in artificial manures. In this selection one was guided by several facts; but the chief were that the bones of the animals were undoubtedly affected, and hence one of the elements forming bone would be probably the one sought for, and the other fact was the high lime-requirement of the soil, which was in the neighbourhood of 1 per cent, whereas the usual figures for North Island soils are from 0.2 to 0.4 per cent. of calcium carbonate.

Other analytical data pointed to excessive soil-sourness and higher organic-matter content than normal soils show. The soil-sourness was determined to be extreme by three analytical tests, viz., the lime-requirement figure (Hutchinson and McLennan's method), the hydrogen-ion concentration (pH) figure, and the replaceable calcium figure, all of which testify to an abnormal soil condition, the remedy for which would be to apply lime. According to Russell "Humus is more sensitive than clay to changes in calcium content and more rapidly becomes neutral on the addition of excessive doses of lime, or conversely more rapidly developes acidity as the lime is washed out." The analysis of this soil shows an excessively high organic-matter content.

It will be interesting to consider what takes place in the soil when a forested country is felled and burnt. The most important chemical effect will result from the distribution over the surface of the land of a dressing of ashes containing carbonate of lime in an infinitely divided state, together with some phosphate and potash. Calcium is the chief element in wood-ashes, potassium being present to a much less extent. The good result accruing from wood-ashes is often attributed to the potash contained in them when the result is more likely due to the lime. There is nothing in the analysis of these soils to show that potash is deficient in them, though the potash fallacy led one farmer to use potash fertilizers on this type of country; but he obtained no evidence of any improvement from potash.

According to data kindly supplied by the Director of Forestry (Mr. E. Phillips-Turner) a burn of forest of the tawa-rimu type might be expected to deposit on the surface of the land from ½ ton to 2 tons of wood-ash per acre, which may be considered a very moderate estimate. Anything like ½ ton to 1 ton of pure fine carbonate of lime per acre on hill land is a dressing not to be despised.

There is considerable evidence as to the elements which are washed out of clay soils from the experience at Rothamsted Experimental Station. These show that potash and phosphate are not leached out of the soil in any considerable quantity, whereas calcium is washed out in very large amounts. Hall, "The Soil," p. 212

states that " phosphoric acid and potash applied as manures are " fixed by the soil whereas the metals sodium and calcium are only " slightly if at all retained. These results are confirmed by the " analysis of the water which flows from the land drains under " normal conditions. This will generally be found to contain nitrates " (and sometimes in fair quantity) sulphates and chlorides of cal- " cium and sodium and considerable amounts of calcium bicarbonate " but rarely shows more than a trace of ammonia, phosphoric acid " and potash."

One may say that the rainfall of this area is heavy and well distributed, so that if we knew of the rapid leaching out of some element necessary to fertility which was present in the soil after the bush burn and then gradually leached out this would be another link in the evidence. That such an element is calcium who can doubt? In the finely-divided condition in which it exists in wood-ashes, whether present as quick lime, slaked lime, or carbonate of lime it would be quickly available and have a greatly ameliorating influence for the first few years and then be leached away or rendered unavailable, the pasture becoming progressively poorer in legumes and the better grasses.

Deficient calcium in the pasture leads to disease in stock. It also probably injuriously affects the growth of bone in the animal, it being the principal constituent in bone-ash. Deficient calcium in this soil would account for the absence of clovers, the component of pastures which supply large quantities of calcium in the feed. Neither nitrates, sulphates, nor chlorides are likely to be so deficient as to cause the malnutrition. That deficient calcium in the soil is reflected in the composition of the grasses growing upon it, and is shown by the analysis of grasses growing near the limestone outcrop and sample growing far away from the influence of lime. The latter are always poorer in calcium than the former.

In the pasture of a typically deteriorated farm that has never had any top-dressing since the burn, one hears that it originally carried rye-grass and clovers, and finds now only Danthonia, browntop, and yorkshire-fog, with traces only of the nutritious Leguminosae, *Lotus major* being the only species visible. That this absence of Leguminosae is a fact and not a cursory impression may be accepted when it is recorded that a skilled assistant, who was sent up in April 1927 to obtain a sample of red or white clover on a 800 acre farm much of which had been top-dressed with phosphates and potash, had to return with the report that he could not even obtain enough to analyze! A pound of the sample would have been ample. It was also reported that swedes and turnips would not thrive unless the soil was limed; and club-root and finger-and-toe in cruciferous plants, grown in either field or garden, was alleged. The pasture was full of moss. Upon pasture that had been limed the sheep were always found grazing. Subsequently it was reported that the very sheep which had been diagnozed as suffering from a deficiency-disease in September 1927, when placed on a limed paddock fattened and were sold fat in a few months. On the other hand, sheep grazed on land which had been liberally top-dressed with phosphates and

potash salts, although the pasture seemed of better quality and of increased carrying capacity, did not respond as they did on the limed paddock.

A growing hogget requires .0093 lb. calcium oxide a day (Wilson). 100 lbs. of the dry matter of the worst Mairoa pasture contains, say, 0.7 lb. CaO. A hogget eats less than 3 lbs. dry-matter a day, or say .021 lb. CaO but can only assimilate one-third to one-half of the mineral matter ingested, hence a figure is arrived at which approaches .009 lb. more or less for summer conditions. In winter the CaO content of the pasture is sure to be lowered and the amount of Ca will fall below the theoretical requirement of .009 lb. per day.

The case of a milking ewe is far worse. She requires .020 lb. CaO daily and if her ingested food only contains .021 lb. there is no margin to allow for calcium not assimilable. Sheep require more lime than cattle in their proportion to the P_2O_5, for while sheep require 1 : 1 ratio, cattle require 1 P_2O_5 to .85 CaO.

The fact that in the aggregate large quantities of phospate had been applied to the land without improving the average quality of the pasture throughout the year sufficiently to enable the flock to develop normally is vouched for by two farmers who had tried that method. That large quantities of phosphate have been applied is indicated by the high phosphate content of the manured land; apart from this one finds that the unmanured land is for hill-pasture country well supplied with available phosphate and particularly well supplied with potash (see analysis of sample W882). In one case the soil was analyzed by taking successive three-inch cores and analyzing the first, second, and third three inches separately, instead of the usual practice of taking one core of 9 inches. This was done in the case of unmanured land on two separate farms. The results show that the soil is well supplied for a hill-soil with available phosphate and potash while the lime-requirement figure is still exceptionally high for all depths (see samples X284-289).

The writer reported on 9th December, 1926, "From what I " could see and ascertain from laboratory tests it seems that lime " is required to improve the composition and texture of the soil, " the lime absorption of most of the soils being about one per cent. " which translated into terms of tons per acre would roughly speak- " ing amount to about ten tons per acre of carbonate of lime. This " is, of course, an empirical laboratory test and by no means to be " taken as indicating that it would be profitable to apply such a " large amount. It is extremely desirable that further investigations " should be made into the best method of reclaiming this fine country " which is rapidly going back to fern. It seems quite probable that " some form of calcium which is alkaline may prove a very strong " agent in bringing this land back to its previous productive " capacity."

The fact that the lime-requirement figure shows an absorption of calcium carbonate approximately equal to ten tons per acre of ground limestone has been advanced as a reason for abandoning the Mairoa lands, since no one could afford to apply this quantity of lime. It is not, however, necessary to satisfy the high lime-require-

ment of ten tons per acre; in fact, the full lime-requirement never is satisfied even when, as in the majority of North Island soils, it is only in the vicinity of two to four tons per acre.

There are several methods which might be tried with the object of avoiding the great expense of liming large tracts of hill-country. These fall under different headings:—

(1.) Cheapening of lime—
   (*a*) By having local grinding-plants for reducing limestone to powder.
   (*b*) By having local kilns for burning limestone.
   (*c*) By giving a subsidy to farmers who cannot take advantage of the free railage because there is no railway. Thus 100 miles free railage is 8/5d. per ton for lime and ground limestone.

(2.) Feeding pellets or licks containing calcium in some available form.

(3.) Bringing up the calcium content of the pasture on one paddock on each farm and running the entire stock periodically through that particular paddock.

STATEMENT OF LIME-REQUIREMENT.

	Per Cent. Carbonate of Lime. On air-dried soil	On moisture free soil	
W/506 Home paddock, Mairoa	1 06	1.15	top-dressed for 4 years.
507 „ „	1 08	1.22	top-dresed for 3 years.
508 „ „	0.35	0 40	close to limestone rock.
509 Oldest clearing „	0.66	0.77	top-dressed for 2 years.
510 „ „	0.81	0.87	top-dressed for 2 years.
511 Subsoil of 512 „	0 89	0.97	not top-dressed.
512 Soil „	0 98	1.09	not top-dressed.
513 Subsoil of W/506 „	0.61	0.67	
514 Moss patches, pdk. W/506	1.09	1.14	badly mossed.

EXPERIMENTAL.

Table 1 shows the chemical analyses of the Mairoa soils. It will be seen that in the top three inches of soil there is ample available phosphate on the unmanured land judged by the usual standards in use for ordinary soils. In the samples taken to a depth of 9 inches and in the composite soil (No. W609) there is no great lack of available phosphate judged by the usual standards. The large amount of organic matter shown by the loss on ignition, however, puts the soil in a class by itself. The outstanding feature of the whole series of soils without exception is the high lime-requirement figure. One might compare the phosphate-content of the Mairoa soils with that of the pumice soils considerably to the disadvantage of the latter on which clover grows abundantly. Bone-nutrition troubles have not been known to occur on pumice soils.

In table 2 are given the results of a series of further analyses of Mairoa soils which substantially bear out the figures of table 1. For a hill-soil, fair amounts of available mineral plant-food are apparently present, but the most important fact is the consistently high lime-requirement figure which is supported by its pH figure. The only exceptions are what one would expect, viz., the soils (X563) drawn round the limestone outcrops which show a lime-requirement figure more nearly approaching a normal North Island acid soil with a pH figure indicating decreased acidity. The other exception is (X553) from a farm usually recognized as superior in quality to the others.

The worst soils for "dopiness," as the local farmers call the disease, are "Farmer O'M," "Farmer McC," and "Farmer N." While the land of "Farmer T" is generally recognized as superior, the samples of soil drawn near the limestone outcrops (separated by lines from the others) are outstanding in their composition compared with the soil away from the influence of limestone.

MAIROA SOILS.

Calcium Oxide.

	Extracted by Citric Acid	Extracted by Hydrochloric Acid	Lime Requirement Figure	pH Figure
"Farmer O'M."				
No. 1 pasture	.15	.59	1.2	5 2
Virgin forest	.23	.74	.89	5 8
Northern paddock	.15	.57	.99	5 3
No. 2 paddock	.13	.65	1.01	5.3
Near limestone	.57	1 63	.38	6.3
"Farmer McC."	.12	.53	.67	5 0
"Farmer N."	.19	.84	.75	5 4
"Farmer N" (Ngapenga No. 2)	.20	.81	.95	5.4
"Farmer T." (good soil)	.39	1.00	.56	6.1

There is a further method by which soils may be examined; the determination of exchangeable bases in the soil or the bases which are instantaneously extracted from the soil on treatment with a solution of a neutral salt. Taking sample X565 the amounts of bases extracted per cent. on the air-dried soil are:—

Ca	Mg	K
0.165	0.024	0.054

This soil is very rich in organic matter (26.6 per cent. loss on ignition) so that a high degree of unsaturation is probably indicated. According to Russell (p. 218) "Humus is more sensitive than clay "to change in calcium content and more rapidly becomes neutral "on the addition of successive doses of lime or conversely more easily develops acidity as the lime is washed out." The same writer (p. 384) gives some interesting figures showing the relation of sour-

ness of soil to the capacity for growing certain plants on it. With a lime-requirement of 0.22 per cent. calcium carbonate on the Harpenden Common, white clover was found to be the dominant growth, of 0.26 per cent. it was fescues, of 0.31 per cent. yarrow, wood rush, and moss, of 0.39 per cent. gorse, of 0.43 yorkshire fog, of 0.53 per cent. sorrel. In the fir woods with lime-requirement of 0.24 the dominant growth was *Mercurialis* (dogs-mercury) but of 0.52 is was yorkshire fog, sweet-vernal, and thistles, of 0.62 fog and anemone. On the Rothamsted grass plots, 1919 results on the most sour soils with a pH figure of 3.79 there was 64.8 per cent. of yorkshire fog (*Holcus lanatus*) in the pasture. Where fog becomes dominant the soil may evidently be unusually sour and in need of lime. (One of the dominant grasses of these Mairoa lands is fog.) Finally Russell in discussing the influence of disease organisms in determining the vegetative characteristics of sour soils finds where there is a pH figure of 5.66 to 6.21 there was much " finger-and-toe" in cruciferae, but where there was a pH figure from 6.13 to 7.9 there was little or no " finger-and-toe." The Mairoa soils are much lighter in texture than those of Rothamsted (a clay with flints), but at Mairoa it is found that with a pH figure of 5.0 to 5 8 finger-and-toe prevents the successful growth of all cruciferous crops attempted. In table 2 are also given the results of two North Island soils of very different types on which dairying is successfully carried on for comparison with the Mairoa soils.

THE PASTURES.

A small number of general pastures and cocksfoot grasses have been analyzed. As would have been expected from a pasture devoid of leguminosae, the calcium and phosphoric acid content of the samples from the unmanured land or from land away from the influence of limestone outcrops is low. Where the pastures have been highly manured by top-dressing with phosphates and potash, or those with ground limestone (6006/6007), calcium and phosphoric acid are present in good proportion and in the right ratio for sheep-feed. Where no top-dressing has been applied (6020/1/2), the amounts of calcium and phosphoric acids are low except where the samples are taken near the limestone outcrops, in which case the calcium is far higher (see Table 3).

In the cocksfoots analysed separately the same low calcium and phosphoric acid content is found, except from around the limestone outcrops and in one of the limed areas where the calcium content is high.

Summing up the evidence which supports liming as an essential to success on the deteriorated volcanic soil of the Mairoa type one may say that,—

(1.) The high " lime-requirement" figure indicating an absorption of nearly one per cent. of lime by laboratory methods.

(2.) The absence of clovers in the pasture in spite of abundance of potash.

(3.) The " finger-and-toe" disease in cruciferous crops.

(4.) The prevalence of moss in the winter pasture.
(5.) The abundance of yorkshire fog in the pasture.
(6.) The avidity with which sheep forsake pasture even well top-dressed with phosphate to feed on a strip of limed pasture in the same paddock.
(7.) The fragile condition of the bones of the animals which show an increase in the organic matter and a diminution of mineral matter.
(8.) The rapid recovery of the same sheep when they are placed on a limed paddock.
(9.) The good results obtained in the years succeeding a burn.
(10.) The fact that pasture growing near the limestone outcrops contains approximately twice as much calcium as that growing away from the influence of the limestone.
(11.) Earth-worms manifest their presence in the recently-limed land to an unusual degree compared with unlimed land where their burrows are inconspicuous.

all show the immediate need of lime to the land.

The conclusion come to from the soil and pasture analysis and the rapid recovery of the ill-nourished animals when placed on limed land is, therefore, that the soil is an abnormally sour one, and that in spite of the fair amount of plant-food present, the clovers cannot flourish, and hence the pasture becomes deficient in the calcium-rich components, the leguminosae, and that lime in some form is necessary to restore the productive capacity to the point at which sheep-farming can profitably be carried on.

The writer's grateful thanks are due to his assistants, F. T. Leighton, R. E. R. Grimmett, C. M. Wright, F. J. A. Brogan, and I. J. Cunningham, for the unremitting attention and enthusiasm with which they have discharged their duties in connection with this investigation; also to Mr. J. Lyons and his staff for their reliable professional advice in connection with the sick stock

REFERENCES.

1927 RUSSELL, E. J., *Soil Conditions and Plant Growth.*
1927 WILSON, JAS., *The Principles of Stock-feeding.*
1908 HALL, A. D., *The Soil.*

TABLE 1.

CHEMICAL ANALYSES.

Results, except*, are percentages on soil dried at 100° C.

Laboratory No.	Locality.	Volatile Matter.			Total Nitrogen.	1% Citric-acid Extract. Dyer's Method, Hall's Modification. ("Available Plant Food.")				Hydrochloric-acid Extract. ("Total Plant Food.")				Lime-requirement. % $CaCO_3$ Hutchinson-Maclennan's Method.	
		*On Air-drying.	*At 100° C.	On Ignition.		Lime, CaO.	Magnesia, MgO.	Potash, K_2O.	Phosphoric Acid, P_2O_5	Lime, CaO.	Magnesia, MgO.	Potash, K_2O	Phosphoric Acid, P_2O_5	On Air-dried Soil.	On Soil dried at 100° C.
X 284	Mairoa Depts. Experimental paddock, Top 3 inches ...	41.6	8.52	31.50	0.791	0.117	0.030	0.022	0.012	0.43	0.40	0.13	0.07	0.98	1.07
285	,, ,, Next 3 inches ...	34.2	21.42	35.30	0.604	0.093	0.016	0.013	0.005	0.34	0.33	0.11	0.04	0.74	0.94
286	,, ,, Lowest 3 inches...	42.2	17.04	30.93	0.527	0.070	0.015	0.011	0.003	0.25	0.32	0.10	0.05	0.78	0.94
287	,, Highest paddock near road, Top 3 inches ...	33.9	13.44	32.37	0.783	0.165	0.043	0.029	0.013	0.51	0.45	0.16	0.14	0.65	0.75
288	,, ,, Next 3 inches ...	28.8	23.20	31.88	0.645	0.125	0.034	0.021	0.008	0.41	0.40	0.15	0.08	0.57	0.74
289	,, ,, Lowest 3 inches...	26.6	12.26	28.17	0.511	0.094	0.026	0.019	0.003	0.32	0.38	0.14	0.11	0.70	0.80
W 512	Soil not top dressed, Mairoa ...	—	—	—	—	—	—	—	0.017	—	—	—	0.07	0.98	1.09
W 609	Composite, Mairoa soils† ... ... W 506, 507, 510, 512, 514	—	8.28	30.09	0.720	0.203	0.041	0.034	0.018	0.51	0.51	0.34	0.08	—	—
W 881	Subsoil of 882	3.7	7.54	21.48	0.309	0.080	0.023	0.028	0.003	0.26	0.63	0.53	0.03	0.72	0.77
882	Topsoil, highest land unmanured ...	4.3	7.62	27.93	0.697	0.165	0.037	0.034	0.012	0.57	0.68	0.46	0.07	0.85	0.92
883	Topsoil, 12 acre paddock	7.1	5.52	23.12	0.501	0.132	0.040	0.019	0.016	0.47	0.71	0.40	0.07	0.74	0.78
884	Subsoil of 883	5.7	5.57	17.54	0.258	0.088	0.022	0.020	0.011	0.29	0.83	0.61	0.06	0.72	0.76
885	Topsoil, Limestone paddock	13.5	8.16	34-23	0.732	0.187	0.032	0.031	0.021	0.39	0.42	0.24	0.11	0.92	1.00
886	Subsoil of 885	12.7	5.36	25.76	0.352	0.091	0.021	0.022	0.008	0.26	0.46	0.28	0.06	0.91	0.96

†Mostly manured.

Analyses by F. J. A. Brogan.

TABLE 2.

CHEMICAL ANALYSES.

Results, except*, are percentages on soil dried at 100° C.

Laboratory No.	Locality.	Volatile Matter.			Total Nitrogen	1 % Citric-acid Extract Dyer's Method, Hall's Modification. ("Available Plant Food.")				Hydrochloric-acid Extract ("Total Plant Food.")				Lime-requirement. % $CaCO_3$		Hydrogen-ion Concentration (pH).
		*On Air-drying.	*At 100° C.	On Ignition.		Lime, CaO.	Magnesia, MgO	Potash, K_2O.	Phosphoric Acid, P_2O_5	Lime, CaO.	Magnesia, MgO.	Potash, K_2O	Phosphoric Acid, P_2O_5	On Air-dried Soil.	On Soil dried at 100° C.	
W 1377	Turakina Valley (loam)		3.0	11.10	0.369	0.296	0.112	0.021	0.017	1.79	1.13	0.86	0.07	0.13	0.13	—
1379	Himatangi (sand)		0.7	3.1	0.075	1.155	0.052	0.016	0.003	†3.41	0.69	0.35	0.01	—	—	—
X 553	Topsoil Otanake		12.9	23.3	0.746	0.391	0.033	0.014	0.006	1.00	0.58	0.27	0.18	.49	.56	6.1
555	„ „ slag-manured		7.5	32.8	0.769	0.150	0.018	0.026	0.008	0.59	0.32	0.12	0.02	1.1	1.2	5.2
557	„ „ unmanured		10.3	30.1	0.830	0.228	0.041	0.032	0.008	0.74	0.38	0.14	0.03	.80	.89	5.8
559	„ „ „		15.3	29.0	0.582	0.154	0.037	0.018	0.005	0.57	0.31	0.12	0.05	.84	.99	5.3
561	„ „ „		19.0	27.3	0.749	0.131	0.027	0.026	0.007	0.65	0.30	0.12	0.03	.82	1.01	5.3
563	„ „ „ (round limestone bluff)		9.8	20.4	0.599	0.573	0.087	0.033	0.007	1.63	0.92	0.34	0.15	.34	.38	6.3
565	Topsoil, Mairoa (unhealthy, unmanured)		8.0	26.6	0.789	0.197	0.041	0.025	0.008	0.84	0.44	0.23	0.03	.69	.75	5.4
567	„ Swamp (comparatively healthy for sheep)		5.0	19.9	0.454	0.200	0.035	0.027	0.017	0.73	0.70	0.39	0.06	.65	.68	5.4
569	„ Ngapaenga, unhealthy		5.7	31.2	0.624	0.205	0.041	0.032	0.009	0.81	0.41	0.15	0.04	.91	.95	5.4
571	„ „ „		8.0	30.3	0.632	0.189	0.034	0.033	0.007	0.83	0.36	0.11	0.02	.91	.99	5.8
573	„ Maungamangero ...		4.9	21.7	0.412	0.174	0.038	0.031	0.010	0.85	0.61	0.28	0.06	.72	.75	5.4
575	„ „ ...		4.6	17.7	0.322	0.120	0.024	0.017	0.008	0.53	0.37	0.16	0.02	.64	.67	5.0
577	„ Waitangururu ...		3.7	21.1	0.511	0.258	0.031	0.013	0.026	0.87	0.64	0.27	0.05	.62	.64	5.8

†Carbonate of lime present.

Analyses by F. J. A. Brogan.

TABLE 3. MAIROA GENERAL PASTURES.

Lab. No.	Locality.	Date Collected	Ash	Sand SiO_2	SiO_2	P_2O_5	CaO	MgO	Mn_3O_4	SO_3	N	Manurial Treatment	Remarks.
6006	Mairoa	10/4/27	12.18	2.13	1.97	1.13	1.20	0.61	0.028	0.92	4.20	6 cwt super. 6 ,, potash No lime	Horse paddock
6007	Mairoa	10/4/27	12.01	1.74	1.64	1.12	1.23	0.60	0.029	1.06	4.[illegible]6	1 ton $CaCO_3$ 4 cwt. potash 2 ,, super.	Ram paddock
6018	Otanake	—/9/27	12.09	4.80	—	0.72	0.85	—	0.013	—	3.31	...	Roadside
6019	Horopupu Road ..	—/9/27	12.24	3.68	3.47	0.87	1.08	—	0.026	—	3.08	...	Limestone outcrop near school
6020	Otanake .. .	—/9/27	10.44	3.12	2.90	0.70	0.59	—	0.057	—	3.37	..	Pdk. No. 1 Sth, side shelter bush
6021	Otanake	—/9/27	10.92	2.19	2.11	0.77	0.66	—	0.047	—	3.47	..	Pdk No. 2. Away from limestone outcrop
6022	Otanake	—/9/27	10.86	1.91	1.82	0.69	0.86	—	0.018	—	4.18	...	Pasture round limestone very gritty
6023	Maungamangero	—/9/27	11.96	2.24	2.04	0.86	1.26	—	0.012	—	3.59	...	Around limestone
6024	Maungamangero	—/9/27	10.82	1.49	1.25	0.83	0.79	—	0.028	—	3.76	...	Away from limestone
6025	Waitangururu ...	—/9/27	12.36	2.50	2.15	0.98	1.40	—	0.026	—	3.53	..	Grass round limestone outcrop. Gritty
8000	Mairoa	10/4/27	11.59	3.66	3.44	0.66	0.83	0.51	0.037	0.82	2.54	Unmanured 21 years old	Yorkshire fog, chewings fescue, danthonia, cats ear, capeweed, piripiri, plantain, etc.

Analyses by B. C. Aston and I. Cunningham.

TABLE 4. MECHANICAL ANALYSES.

Results are percentages on air-dried soil.

Laboratory No.	Description of Soil (Classification of U.S Dept. of Agriculture, modified)	Analysis of "Fine Earth" passing 2 mm. Sieve							Stones and Gravel	
		Fine Gravel.	Coarse Sand	Fine Sand.	Silt	Fine Silt.	Clay.	Moisture and Loss on Ignition.		
W 609	Loam	0.5	9 4	15 0	14 1	12.3	15.1	8.3 27.6		Composite sample

The New Zealand Species of *Metrosideros* with a Note on *Metrosideros collina* (Forst) Gray.

By W. R. B. OLIVER, M.Sc., F.N.Z. Inst., Director Dominion Museum, Wellington.

[*Read before the Wellington Philosophical Society, 24th June, 1928; received by Editor, 31st July, 1928; issued separately, 31st August, 1928.*]

PLATE 67.

THE purpose of the present paper is merely to revise the nomenclature of the New Zealand species of *Metrosideros.* Discussions on affinities and distributions are therefore included only so far as they have a bearing on the name to be applied to the species. Investigations into the nomenclature of the genus revealed an amazing state of confusion, for, as will be seen by what follows, no fewer than seven of the eleven names used in Cheeseman's *Manual of the New Zealand Flora* will require to be changed. Unfortunately, in two cases the names are transferred to different species within the genus.

It will be convenient to compare in tabular form the names herein proposed with those in Cheeseman's Flora.

Cheeseman's *Manual.*	Present Paper.
M. florida	*M. scandens*
M. lucida	*M. umbellata*
M. Parkinsonii	*M. Parkinsonii*
M. albiflora	*M. albiflora*
M. diffusa	*M. carminea*
M. hypericifolia	*M. diffusa*
M. Colensoi	*M. Colensoi*
M. scandens	*M. perforata*
M. robusta	*M. robusta*
M. robusta var. *intermedia*	× *M. subtomentosa*
M. tomentosa	*M. excelsa*
M. villosa	*M. kermadecensis*

Of the above changes *M. perforata* has already been noticed recently by the author and by Cockayne and Allan (*Trans. N.Z. Inst.*, vol. 56, pp. 5, 27, 1926), while *M. scandens* (= *M. florida*) was recorded by Druce in 1917. In the case of the hybrid, *M. subtomentosa,* this name is adopted instead of *intermedia* under the authority of a rule which states that the first name used in a specific sense must stand. The rule is obviously not in harmony with the law of priority.

In order to verify the results of my researches, I applied to the Department of Botany of the British Museum where the types of the Forsters are preserved. Mr. A. W. Exell kindly took the matter up, fully investigated the problems I placed before him, and drew up a synonymy which not only confirmed mine but added several references not available to me. Thanks to Mr. Exell, therefore, I believe the names now put forward are in accordance with the International Rules of Botanical Nomenclature, and the authori-

ties given are correctly stated. Mr. Exell kindly examined the type specimens in the British Museum and in the Linnean herbarium.

Metrosideros scandens (Forst.) Druce.

Leptospermum scandens Forst. *Char. Gen.* 72, pl. 36, 1776.
Melaleuca florida Forst. *Fl. Ins. Austr. Prodr.* 37, 1786.
Metrosideros fulgens Sol. ex Gaertn. *Fruct. Sem. Pl.* 1, 172, pl. 34, f. 7, 1788.
M. florida Smith, *Trans. Linn. Soc.* 3, 269, 1797.
M. speciosa Colenso, *Trans. N.Z. Inst.*, 22, 463, 1890.
M. aurata Colenso, *Trans. N.Z. Inst.*, 23, 385, 1891.
M. scandens Druce, *Rep. Bot. Exch. Cl. Br. Isles,* 1916, 635, 1917.
Not *M. scandens* Sol. ex Gaertn. *Fruct. Sem.*, pl. 1, 172, 1788.

The Forsters introduced *Leptospermum scandens* twelve years before Gaertner founded *Metrosideros scandens* for a different species. As Gaertner's specific name is not valid, being pre-occupied by Forster's earlier *perforatum,* Forster's name *scandens* becomes available for the present species.

Metrosideros umbellata Cav.

Melaleuca lucida Forst. *Fl. Ins. Austr. Prodr.* 38, 1786.
Metrosideros umbellata Cav. *Ic. Desc. Pl.* 4, 20, pl. 337, 1795.
Melaleuca umbellata Raeusch, *Nomencl. Bot.* ed. 3, 143, 1797.
Metrosideros lucida A. Rich. *Voy. Astrol.* Bot. 333, 1832.
Agalmanthus umbellatus Hombr. & Jacq. ex Decne. *Voy. Astrol. et Zel.* 78, 1853.
Not *Melaleuca lucida* Linne. f. Suppe. 342, 1781.

Forster's specific name *lucida* is not valid for this species on account of an earlier homonym of Linne f. (= *M. collina.*). Cavanille's name *umbellata* therefore comes into use.

Metrosideros Parkinsonii Buch.

Metrosideros Parkinsonii Buchanan, *Trans. N.Z. Inst.*, 15, 339, 1883.

Metrosideros albiflora Sol. ex Gaertn.

Metrosideros albiflora Sol. ex Gaertn. *Fruct. Sem. Pl.* 1, 72, pl. 34, f. 11, 1788.
Melaleuca albiflora Raeunch, *Nomencl. Bot.* ed. 3, 143, 1797.
Metrosideros diffusa A. Cunn., *Ann. Nat. Hist.* 3, 114, 1839. Hook f. *Ic. Pl.* pl. 569, 1843. Not *M. diffusa* Smith. *Trans. Linn. Soc.* 3, 268, 1797.

Metrosideros carminea W. R. Oliv. new name.
Metrosideros diffusa Hook. f., *Fl. Nov. Zel.* 1, 67, 1853. Not. *M. diffusa* Smith, *Trans. Linn. Soc.* 3, 268, 1797, nor *Melaleuca diffusa* Forst. *Fl. Ins. Austr. Prodr.* 37, 1786.

This species has been known under the name of *M. diffusa* since the publication of Hooker's *Flora Novae Zelandie* in 1853. It is not however the *Melaleuca diffusa* of Forster, better known as *M. hypericifolia,* nor the *Metrosideros diffusa* of Smith, which is a Polynesian species (*M. collina*), nor yet *M. diffusa* of Cunningham, which

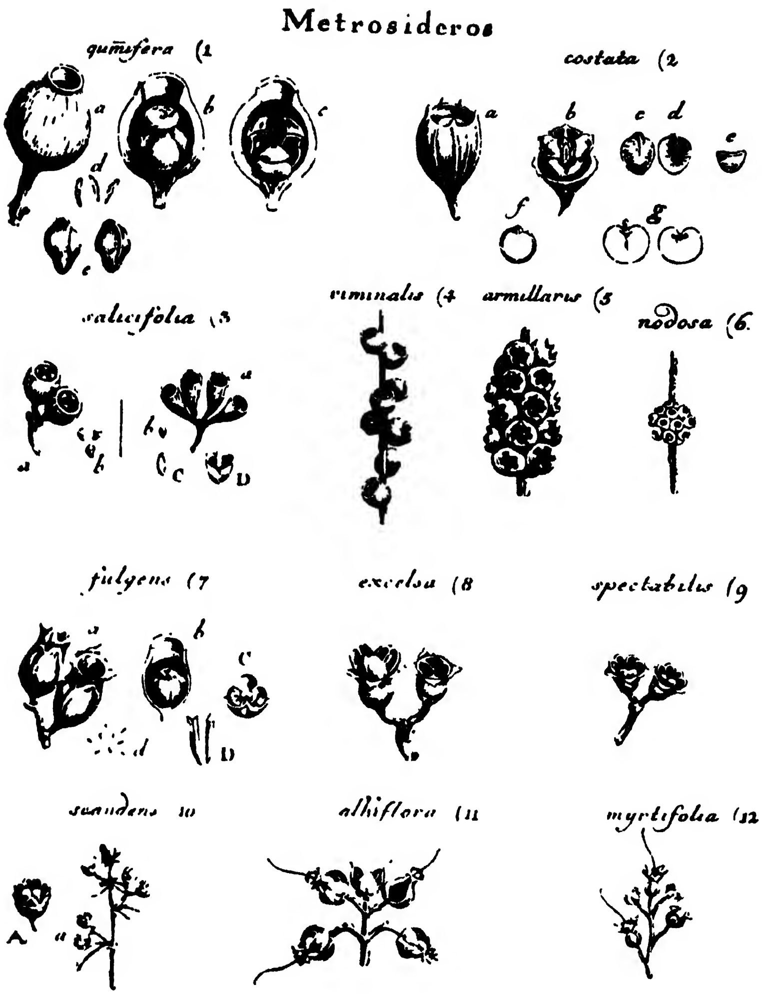


Plate 34 of Gaertner's *De Fructibus et Seminibus Plantarum*, 1788.

is *M. albiflora.* The name *diffusa* has thus been applied to four different species of *Metrosideros.*

Forster did not land at any point in the North Island, so that his name could not rightly be applied to the present species which is confined to the northern portion of that island.

Metrosideros diffusa (Forst.) W. R. Oliv. new comb.
Melaleuca diffusa Forst. *Fl. Ins. Austr. Prodr.* 37, 1786.
Metrosideros myrtifolia Sol. ex Gaertn. *Fruct. Sem. Pl.* 1, 172, pl. 34, f. 12, 1788.
M. hypericifolia A. Cunn. *Ann. Nat. Hist.* 3, 114, 1839.
M. subsimilis Col. *Trans. N.Z. Inst.*, 12, 361, 1880.

Cheeseman in his *Illustrations of the New Zealand Flora,* pl. 48, 1914, discusses the identity of *Melaleuca diffusa,* of Forster and concludes that " in all probability his plant is identical with the species usually known as *M. hypericifolia.*" In order to verify this I sent to Mr. Excell specimens illustrating the range of variation of *M. hypericifolia.* Mr. Excell kindly compared the specimens with Forster's type and reported that they belonged to the same species.

Metrosideros diffusa of Smith, is, as shown under *M. collina* not the same as Forster's *Melaleuca diffusa.*

Metrosideros myrtifolia of Gaertner is as shown by his plate reproduced herewith the same species as Forster's *Melaleuca diffusa.*

Metrosideros Colensoi Hook. f.

Metrosideros Colensoi Hook. f. *Fl. Nov. Zel.* 1, 68, 1853.
M. pendens Colenso, *Trans. N.Z. Inst.*, 12, 360, 1880.

Metrosideros perforata (Forst.) Rich.

Leptospermum perforatum Forst. *Char. Gen.* 72, 1776.
Melaleuca perforata Forst. *Fl. Ins. Austr. Prodr.* 37, 1786.
Metrosideros scandens Sol. ex Gaertn. *Fruct. Sem. Pl.* 1, 172, pl. 34, f. 10, 1788.
M. perforata A. Rich. *Voy. Astrol.* Bot. 334, 1832.
M. buxifolia A. Cunn. *Ann. Nat. Hist.* 3, 111, 1839.
M. vesiculata Colenso, *Trans. N.Z. Inst.*, 16, 327, 1884.
M. tenuifolia Colenso, *l.c.* 24, 387, 1892.

Not *Leptospermum scandens* Forst. *Char. Gen.* 72, 1776.

I have myself examined Forster's type of *Melaleuca perforata,* and found it to agree with the plant known to New Zealand botanists as *Metrosideros scandens.* Gaertner's *Metrosideros scandens,* which should not be confused with Forster's *Leptospermum scandens,* is shown, by Gaertner's plate reproduced herewith, to be the present species.

Metrosideros robusta A. Cunn.

Metrosideros robusta A. Cunn. *Ann. Nat. Hist.* 3, 112, 1839.
M. florida Hook. f. *Bot. Mag.* pl. 4471, 1849 (not Forst.)
M. robusta var. *retusa* Kirk, *Students Fl. N.Z.* 162, 1899.

× **M. subtomentosa** Carse.

Metrosideros robusta var. *intermedia* Kirk. *Students Flora,* 162, 1899.
× *M. subtomentosa* Carse, *Trans. N.Z. Inst.*, 57, 92, 1927.

This hybrid was first described by Kirk as a variety of *M. robusta.* Kirk's specimens were collected on Rangitoto Island where both *M. robusta* and *M. excelsa* are found. There are also in his herbarium similar specimens from Great Omaha, where this form is known to bushmen as the "inland pohutukawa." Plants of different appearance, but intermediate between *M. robusta* and *M. excelsa* have been collected at Titirangi, Mount Tarawera, and Taupo Lake, in every case localities where both *M. robusta* and *M. excelsa* are found, so that their hybrid origin is practically certain.

Metrosideros excelsa Sol. ex Gaertn.

Metrosideros excelsa Sol. ex Gaertn. *Fruct. Sem. Pl.* 1, 172, pl. 34, f. 8, 1788.

M. tomentosa Rich. *Voy. Astrol.* Bot. 336, pl. 37, 1832.

My attention was first drawn to the identity of *M. excelsa* through the examination of specimens in the Dominion Museum herbarium collected by Banks and Solander during Cook's first voyage. The specimens were labelled *Metrosideros excelsa.*

In order to verify the identification I applied to Professor J. Arthur Harris, of the University of Minnesota, who kindly sent me a typed copy of the Gaertner's description of *M. excelsa* and a photographic reproduction of his plate 34. The description runs: "Calyx tomentosus, quinquedentatus, capsulae ad medium usque adnatus. Capsula ovata, extra calycem prominens, pubescens, trilocularis." The plate is reproduced herewith. There can be no doubt that Gaertner's plant, which was collected by Banks and Solander, is that commonly known as *M. tomentosa.* Mr. Exell is in agreement with me.

Metrosideros kermadecensis W. R. Oliv. new name

Metrosideros polymorpha Hook f. *Handb. N.Z. Fl.* 73, 1864, (not Gaud).

M. villosa Kirk, *Students Fl. N.Z.* 163, 1899 (not Sm.).

This species has hitherto been referred to the very complex group known collectively under the name *Metrosideros collina* (Forst.) Gray, or one of its numerous aliases, and which is found throughout the Pacific from Fiji to Tahiti and the Hawaiian Islands

Leaving aside the Kermadec species, *M. collina* may be divided into two groups, one confined to the Hawaiian Islands and consisting of 11 varieties, and another found in the South Pacific Islands and separable into three varieties. In the latter group I have seen no form corresponding to the Kermadec plant. Throughout its range it is for the most part either entirely glabrous or it has the inflorescence, young leaves, and to a greater or lesser extent, the undersurface of the leaves, canescent or tomentose. Moreover the leaves are typically elliptic, moderately thin and have flat margins. The Kermadec species has oblong coriaceous leaves with recurved margins and is densely tomentose below. The inflorescence and young leaves are also densely covered with white tomentum. In both *M. collina* and *M. kermadecensis* the flowers are sessile.

To find a form within the complex *collina* at all comparable with the Kermadec species it is necessary to go to Hawaii where the variety *incana* approaches it. But this variety differs from *M. kermadecensis* in its larger leaves with longer petioles and pedicellate flowers. Moreover it is generally an erect tree with grey bark, and

with the capsule slightly exserted or immersed in the calyx-tube, from which it is nearly free. The variety *incana* is said to come close to the variety *typica* which has cordate leaves, and if these and the other named varieties are properly included in a single species then its genetic constitution is entirely different from that of the South Pacific group and still more so from the Kermadec species. *M. kermadecensis* is really a close ally of *M. excelsa* of New Zealand, differing mainly in its smaller oblong leaves and smaller flowers.

NOTE ON **Metrosideros collina** (FORST) GRAY.

As the nomenclature of this species is involved in that of some of the New Zealand species, the following remarks are worthy of record in this place.

At my request Mr. Exell kindly examined for me the type of *Melaleuca lucida* in the Linnean herbarium. He reports that it agrees well with *Leptospermum collinum* of Forster. It was collected by Sparrman and given to Linné. Though it was said to have come from New Zealand it was probably collected at Tahiti.

As there has been a considerable amount of confusion through the application of the name *diffusa* to New Zealand species of *Metrosideros,* I applied to Dr. Daydon Jackson for particulars of the specimens in Smith's herbarium. I received back extracts of Smith's account in Volume 3 of the *Transactions of the Linnean Society,* and a tracing of the specimen in Smith's herbarium with a copy of the label attached thereto. The tracing might well be *M. collina.* Smith in his account states that he had seen the specimen given by Sparrman to Linné, and then synonymizes *Melaleuca lucida* Linn. with his *diffusa.* But *M. lucida* Linn. is as above stated, *Metrosideros collina.* The label of Smith's specimen reads "Otateite, Nelson. Herb. Banks, 1797." Otateiti is a form of Tahiti. "Nelson" must be a late addition as the place so called in New Zealand would not be named for more than forty years after Smith's account was published. Although Smith uses Forster's name *diffusa* he evidently had not seen Forster's type, for he states that "I have only seen one specimen which was given to Linneaus by Dr. Sparrman" (that is, *M. lucida* Linn.). From this it is clear that Smith's *Metrosideros diffusa* is identical with *Leptospermum collinum* of Forster. Finally, Hooker and Arnott identify Tahiti specimens with Smith's *diffusa.*

The synonymy of the Hawaiian group, which I recommend it would be convenient to call *M. polymorpha* Gaud, as was done by Gray, is given fully by Rock in *The Ohia Lehua Trees of Hawaii.* The following synonymy covers the South Pacific Group, all the names except *vitiensis* being founded on Tahiti specimens. *Leptospermum collinum* Forst. *Char. Gen.* 72, pl. 36, 1776. *Melaleuca lucida* Linn. f. *Suppl. Pl.* 342, 1781. *M. villosa* Linn. f. *l.c.* *M. aestuosa* Forst. *Fl. Ins. Austr. Prodr.* 38, 1786. *Metrosideros spectabilis* Sol. ex Gaertn. *Fruct. Sem. Pl.* 1, 172, pl. 34, f. 9, 1788. *M. villosa* Smith, *Trans. Linn Soc.* 3, 268, 1797. *M. diffusa* Smith *l.c.* Hook. & Arn. *Bot. Beech. Voy.* p. 63, 1841 (not Forst.). *M. villosa* var. *glaberrima* Bertero ex Guill. *Zeph. Tait.* p. 57. *M. collina* Gray, *Bot. U.S. Expl. Exp.* 558, pl. 68, 1854. *M. collina* var. *vitiensis* Gray *l.c.* p. 559. *M. tahitiensis* Decne., *Bot. Voy. Venus,* p. 30, 1855. *Nania collina* O. Ktze, *Rev. Gen. Pl.* 1, 242, 1891.

Amendments to the International Rules of Zoological Nomenclature.

(Reprinted from *Nature*, 7th January, 1928, pp. 12-13.)

"Upon unanimous recommendation by the International Commission on Zoological Nomenclature, the International Zoological Congress which met at Budapest, Hungary, September, 4-9, 1927, adopted a very important amendment to Article 25 (Law of Priority) which makes this Article, as amended, read as follows (*italicised type represents the amendments*; Roman type represents the old wording):

Article 25.—The valid name of a genus or species can be only that name under which it was first designated on the condition:

(a) That (*prior to January 1, 1931*) this name was published and accompanied by an indication, or a definition, or a description; and

(b) That the author has applied the principles of binary nomenclature.

(c) *But no generic name nor specific name published after December 31, 1930, shall have any status of availability (hence also of validity) under the Rules, unless and until it is published either*

(1) *With a summary of characters (seu diagnosis; seu definition seu condensed description) which differentiate or distinguish the genus or the species from other genera or species.*

(2) *Or with a definite bibliographic reference to such summary of characters (seu diagnoses; seu definition; seu condensed description). And further,*

(3) *In the case of a generic name, with the definite unambiguous designation of the type species (seu genotype; seu auto-genotype; seu orthotype).*

The purpose of this amendment is to inhibit two of the most important factors which heretofore have produced confusion in scientific names. The date, Jan. 1, 1931, was selected (instead of making the amendment immediately effective) in order to give authors ample opportunity to accommodate themselves to the new rule.

The Commission unanimously adopted the following resolution:

(a) It is requested that an author who publishes a name as new shall definitely state that it is new, that this be stated in only one (i.e., in the first) publication, and that the date of publication be not added to the name in its first publication.

(b) It is requested that an author who *quotes* a generic name, or a specific name, or a subspecific name, shall add at least once the author and year of publication of the quoted name or a full bibliographic reference.

The foregoing resolution was adopted in order to inhibit the confusion which has frequently resulted from the fact that authors have occasionally published a given name as 'new' in two to five or more different articles of different dates—up to five years in exceptional cases."

(Signed) C. W. Stiles,
Secretary to Commission.

United States Public Health Service,
Washington, D.C.

Cause of Fishiness in Dairy Products.

(Extract from *Nature*, 3rd March, 1928.)

The action of Fenton's reagent (hydrogen peroxide in the presence of small amounts of ferrous salt) on lecithins in alcoholic solution causes the oxidation of the choline and amino-ethyl alcohol portions to tri-methylamine and methylamine respectively (together with some ammonia).

The olein of butterfat, owing to its unsaturation, easily absorbs oxygen to form a labile peroxide, the absorption being strongly catalyzed by compounds of heavy metals, especially copper. The peroxide thus formed is an active oxidizing agent in fatty media and is also a catalyst to more advanced oxidation. Lecithin is intimately associated with the fat peroxide in the fat phase of dairy products, and its nitrogenous base portion is oxidized through the agencies of the fat peroxide and the catalytic activity of the metallic (copper) componds present, forming volatile bases possessing a fishy odour. That is, the reaction involved is a modified Fenton reaction in the fat phase. These volatile bases (tri-methylamine mostly) together with the easily hydrolysable salts of these bases with free fatty acids (butyric and oleic), are the causes of fishy flavours and smells in dairy products.

The importance of small amounts of metallic compounds, copper especially, in strongly catalyzing the oxidation must be realized, since, without metallic contamination, the formation of labile peroxide would be slow, and, since rancidity is a precursor to fishiness, that degree of rancidity necessary for fishiness to develop would not have been reached during the normal storage of products free from metallic contamination. In the examination of all products which were fishy, copper in appreciable quantity has been found to be present.

That such oxidation is possible in butterfat also demonstrates the need of enquiry into the fate of fat-soluble vitamins during the development of rancidity.

(Signed) W. L. Davies.
A. T. R. Mettick.

The National Institute for Research in Dairying,
University of Reading, February 7th.

"The New Zealand Glow-worm."

Boletophila (Arachnocampa) luminosa.

(Extract from the *Annals and Magazine of Natural History.* Ser. 9, vol. 17, p. 228, February 1926, and Ser. 9, vol. 18, p. 667, December 1926.)

Mr. G. V. Hudson summarizes results of observations begun by him in January 1885 on New Zealand Glow-worms. He reared flies (both females) from the larvae in 1889 and 1890, description of the fly by Skuse, who named it *Boletophila luminosa,* appearing in *Trans. N.Z. Inst.,* vol. 23, 1890, p. 47. The type-specimen was deposited in the Australian Museum, Sydney, the other being retained in Mr. Hudson's own collection. Another fly, again a female, was reared in September, 1926. Of this specimen, both the imago and pupal skin have been deposited in the British Museum.

Details as regards the web spun by the larvae and the food captured by them were observed by Mr. A. Norris, a pupil of Mr. Hudson's, during the years 1892, 1893, and 1894, and a note sent by him to the *Entomologists' Monthly Magazine* appeared in September 1894, p. 202. This note is as follows:—

"I have observed the larvae in their natural haunts forming their webs, which consist of a kind of mucus, which is discharged from all parts of the body. If you take a larva from its web and put it on the ground, it will stay there until it has discharged enough of this mucus from which to slide out. Wherever it goes it leaves a mark in the same way as the snail. When the larva is making a fresh web, it raises its head and first four or five segments in the air, and reaches round about until it strikes something. It then draws its head back a little way, thus making a very fine thread of mucus. It then passes it to the thick mucus on the first segment, then slides out a little way, and makes another thread on the other side in the same way, fastening each to the thick mucus on the body. When it has made a sufficient number of these braces, it begins to make the strings of beads which hang downwards from these braces by gliding out of the braces, and lowering its head and about half the body. It then works its head and body up and down as if to vomit. You can see the mucus gathering on the body. Then it draws its head right back into the first two segments, as if it were turning inside out. It then catches hold of the mucus on the edge of the segment, and forces it forward. Now the head is out straight, with a large drop of mucus all round it like a drop of water. Then it draws its head gently out of the mucus, thus making a short fine thread from it. It then makes another drop, and another short thread; then a drop, and so on, until it has made several of these pendants of beads, which may vary in length. I have seen them from one inch to four or five inches. I believe in caves, where there is no wind, they reach the length of two feet. At night, when the larva is shining, you can see the reflection of the light for a considerable distance along the main thread or *tube.* When it is in a small

cave, the light also reflects on the pendants of beads, thus lighting up the whole of the cave. I call it the main *tube,* because the larva does not rest on the thread, but glides through it, which can easily be seen when the larva is in the centre of the thread, or tube, and tries to get out through the side. You can see it pushing, and moving its head about as if to break the side of the tube before it gets out.

" It is my belief that the web is formed to entangle insects, which are attracted by the light.

" The following are my reasons. I have frequently found small Diptera, Coleoptera, Lepidoptera, and a great many of the Crustacea entangled in the sticky web of the larva (which is very strong). I have also noticed that several of the Coleoptera, when taken out of the webs, were hollow, showing that the interior had been extracted in some way. When the insects are alive, the larva may be seen smothering them with mucus. On the 17th February, 1894, I saw that one of the larvae had a crustacean in the web. The larva's head was thrust inside the shell of the crustacean, I at once used the lens, and could plainly see the mandibles working, and that the larva was eating the animal. I blew the web gently, when the larva at once stopped eating, but proceeded again. Again I blew, but harder, when it at once retreated, taking the animal part of the way with it. There are frequently fragments of insects to be seen stuck on the rocks at the sides of the webs, as if, when a larva had finished an insect, he turned it out of the web, and was ready for more.

"The ♂ and ♀ can easily be distingushed in the pupa. In the first place, the male is much smaller and not so stout as the ♀, and the end of the ♂ abdomen is very abrupt. On the other hand, the ♀ is much stouter, and the end of the abdomen comes to a point and has two small fans. Both larvae and pupae are luminous, the ♀ being so in all three stages. The ♂ is luminous in the pupa until the last two or three days before it hatches. I have three males, and none of them was luminous in the imago.

"Wellington, N.Z., May 1894."

Mr. Norris also observed that a hymenopterous insect, with an apterous female, *Betyla fulva,* Cameron, is parasitic on the N.Z. glow-worm (See *Trans. N.Z. Inst.,* vol. 25, 1892, p. 164, and the *Entomologists' Monthly Mazagine,* November, 1892.)

During Mr. Hudson's 1926 investigations, the small flies he introduced, mostly Mycetophilidae, half a dozen at a time every three or four days, invariably disappeared, their remains being on several occasions detected in the webs or on the surface of stones close by. Mr. Hudson states: " I have been able to observe the larvae at all hours of the night. The light is, as previously stated, always brighter on dark, warm, damp nights, but it is invariably at its brightest immediately before daybreak. I have noticed this on many occasions. I consider my latest observations absolutely prove that the larvae are carnivorous and that the light attracts, and the web entangles, the small flies on which the larva feeds. There was, in fact, practically nothing else in the tank which could have sustained the larvae during the three and a half months they have been in captivity, and

the speedy disappearance of the numerous flies so frequently introduced further confirms this view."

He has also detected the larva apparently feeding on the pupa: "On several occasions I observed the head of the larva in contact with the pupa, but could not see if it was actually feeding on the same. During the last ten days, however, the pupa has gradually shrivelled up and it is now almost an empty skin, the larva having increased in size during the same interval. It is clear that the larva has fed upon the juices of the pupa, and, from the very close proximity in which we always find the glow-worms in a state of nature, it is practically certain that these cannibalistic habits must at times occur under natural conditions."

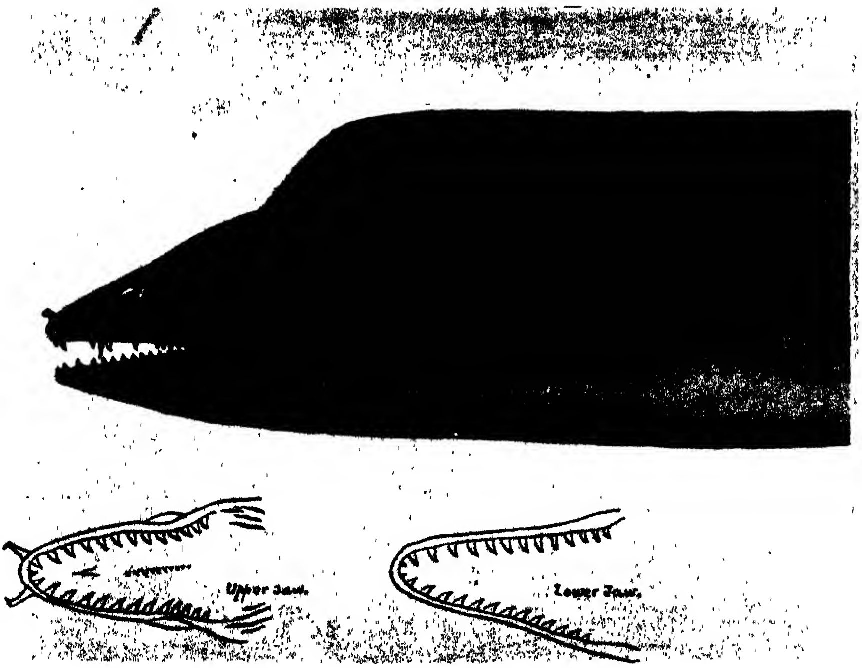
He describes the emergence of the fly:—

"September 26th (1926).—Since my note of the 12th instant the pupa referred to has, at irregular intervals, emitted a strong light from its posterior extremity. On the morning of September 24th the perfect fly emerged, a ♀. During emergence the pupa assumes an almost horizontal position, and as the imago protrudes from the pupa its head comes downwards, the thoracic attachment of the pupa acting as a fulcrum. First, the wings are drawn clear, afterwards the legs. In the final stage of emergence the head of the imago is directed downwards, the tail of the pupa pointing slightly upwards, the pupal attachment occupying an intermediate position. When finally clear the imago stands on the pupal skin, with the extremity of its abdomen still within the exuvia, the pupal skin resuming its original vertical position.

"At 4 p.m. on the 24th I detached the exuvia from the rock, and removed it and the perfect insect into a small caterpillar cage. During the ensuing night the anal extremity of the fly was observed to be strongly luminous and apparently continuously so."

Both the larva and the female fly emit the light; the organ emitting it being situated at the posterior end; it is concluded from experiment that the light of the larva is for the purpose of attracting insects; that of the female may be for sexual attraction.

Further details and figures may be seen in the reference above, and in Hudson's *Elementary Manual of New Zealand Entomology*, 1892.


Upper Jaw.
Lower Jaw.

L. T. Griffin del.

FIG. 2.—*Hoplostethus elongatus* Gunth.

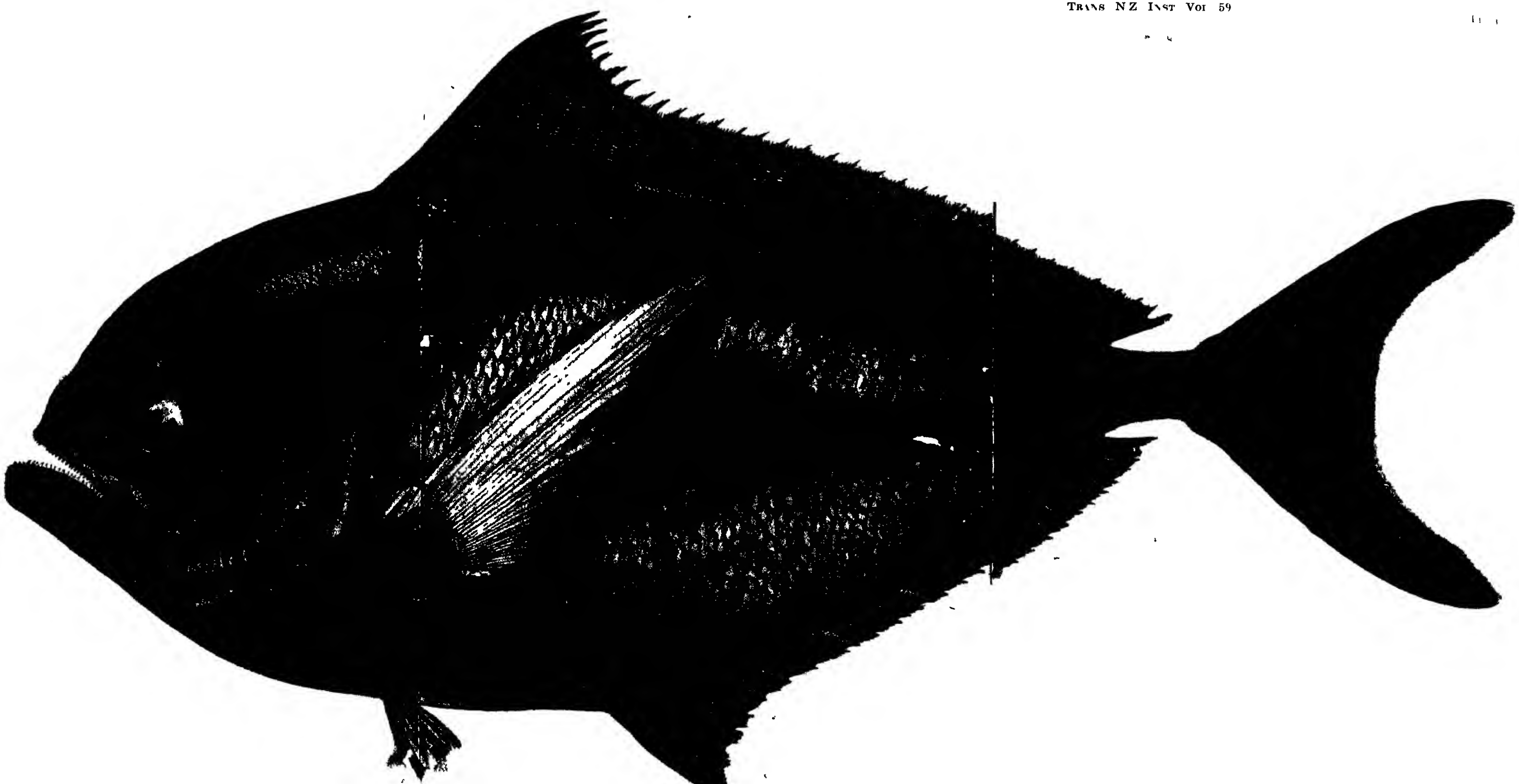


Fig 4—*Brama raii*

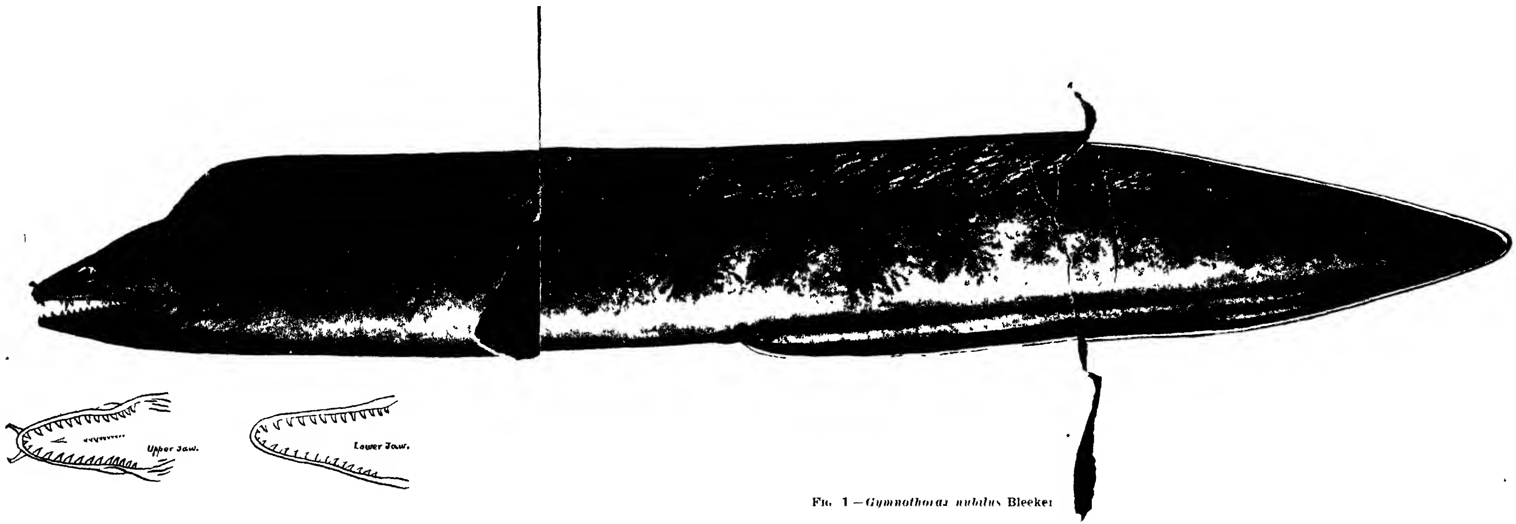
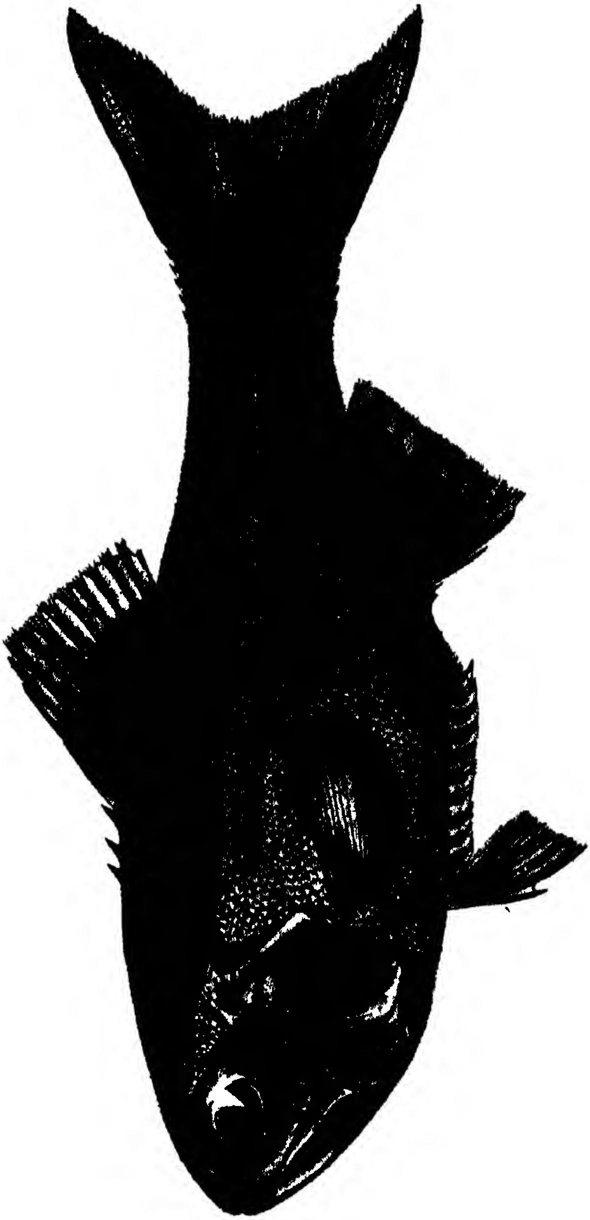


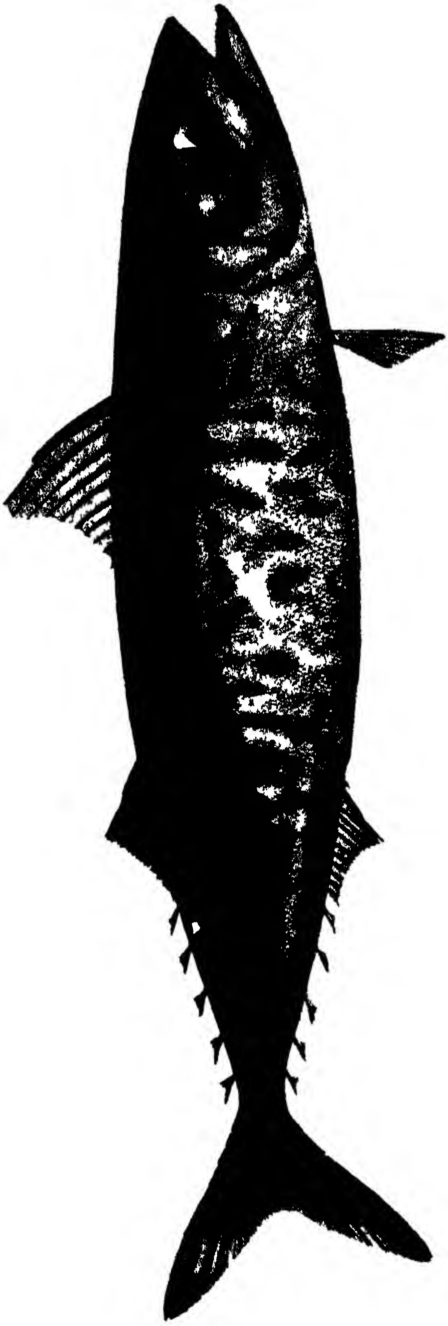
Fig. 1 — *Gymnothorax nubilus* Bleeker

L. T. Griffin del



J. I. Griffin del.

FIG. 2.—*Hoplostethus elongatus* Gunth.



L. T. Griffin del.

FIG. 7.—*Scomber australasicus* Cuv. et Val.

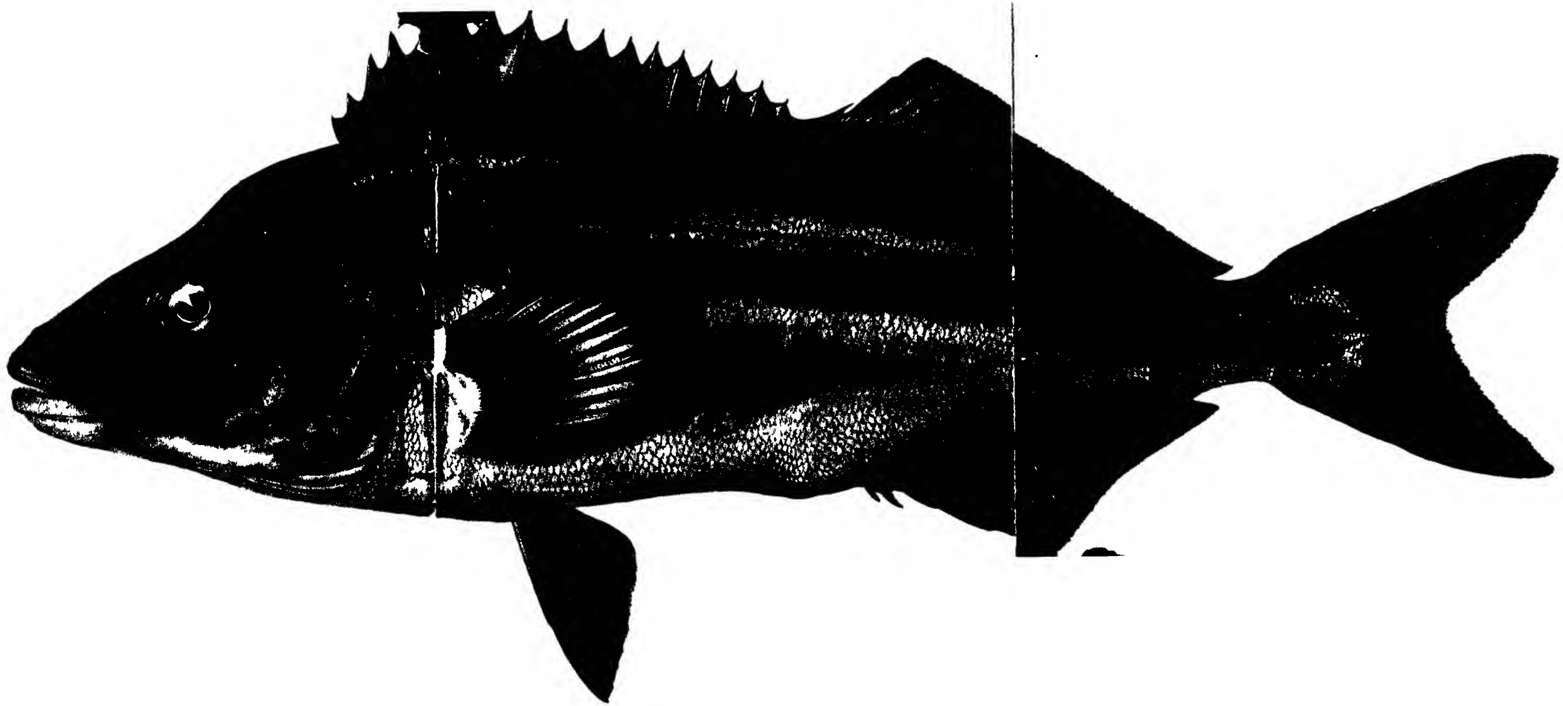
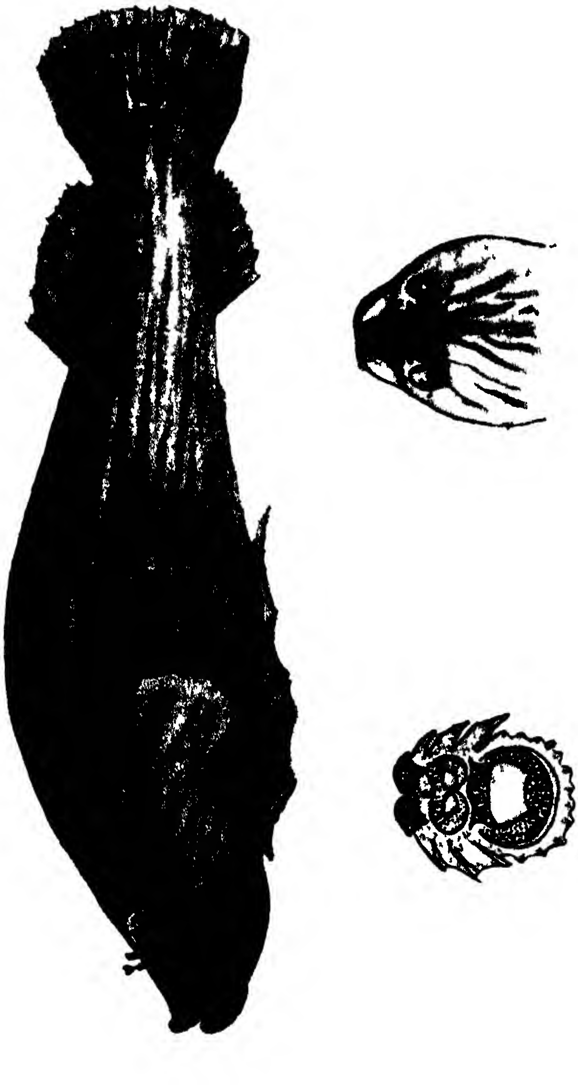


Fig. 6. *Latris lineata.*

Fig. 8.—*Diplacrepis puniceus* Richardson.

L. T. Griffin del.



L. T. Griffin, del.

FIG. 9.—*Diplocrepis tumidus* n. sp.

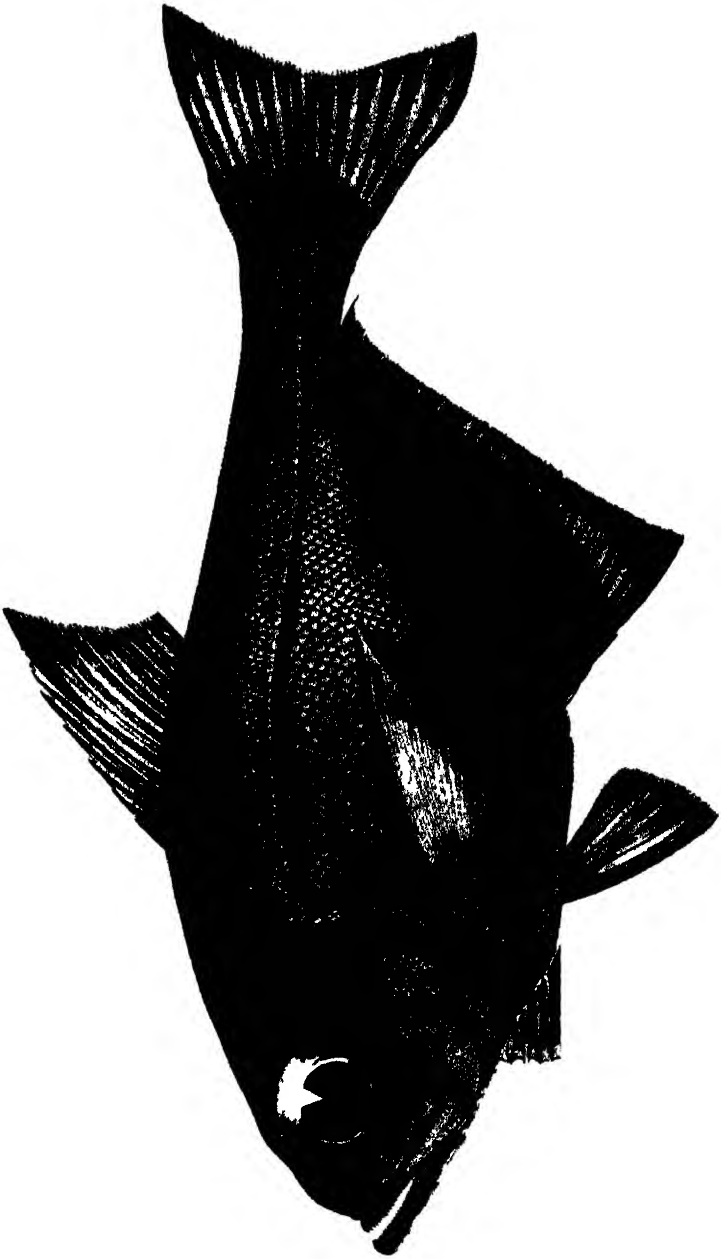


FIG 5 —*Pempheris compressa*

L T Griffin del

L. T. Griffin del.

Fig. 10.—*Antennarius striatus* Shaw.

TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

VOL. 59
(QUARTERLY ISSUE)
Part 3, SEPTEMBER, 1928

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

ISSUED 30th NOVEMBER, 1928

Wellington, N.Z.
FERGUSON & OSBORN LTD 202 LAMBTON QUAY
WHELDON & WESLEY, Ltd 2, 3, and 4 Arthur Street New Oxford Street London W C

CONTENTS

PART 3, 1928.

BOTANY.

GEOLOGY.

ZOOLOGY.

MISCELLANEOUS.

ABSTRACT.

LIST OF PLATES.

The Orbit of the Comet 1927 *k*. (Skjellerup).

By P. W. Glover, New Plymouth Observatory.

[*Read before the Philosophical Institute of Canterbury 6th June, 1928; received by Editor, 8th June, 1928; issued separately, 13th October, 1928.*]

There have been many claims to the discovery of this comet, but unfortunately for the claimants, reports were not sent to the nearest observatories till long after the news had appeared in the daily papers. The three first recorded observations were by Skjellerup—a veteran comet searcher late of South Africa—at Melbourne, on December 3.7292 G.M.T., for which the observed position was 16h. 12m. 12s. Right Ascension, and 53° 57′ South Declination; by Rhind at New Plymouth, on December 4.6389, when the position by sextant was 16h. 17m. R.A., and 52° 43′ S. Dec., and by Maristany at La Plata, who gave for its position on December 6.0250 G.M.T. as 16h. 27m. R.A., 50° 00′ S. Dec. It was remarkable that such a brilliant comet as this happened to be, should have been so badly situated for observation; and, indeed, Professor van Biesbroeck[1] considered it to have come very close to fulfilling those geometrical conditions which would have rendered its observation impossible. Apart from this, it was found impossible to make micrometric measures of the position, and so the early observations, with three exceptions, consisted merely of circle readings corrected for index error and refraction. Of the three exceptions mentioned, two were the observations by McIntosh at Auckland with a fourteen-inch reflecting telescope, the other being Rhind's sextant observation. Mr. McIntosh made careful drawings of the position of the comet with respect to a number of small stars (between the 8th and 10th magnitude) in the field. For his observation on December 5.6458 G.M.T., the stars were identified in the Cape Photographic Durchmusterung by Dr. Crommelin[2], who gave for the position of the comet at that time, R.A. = 16h. 27m. 0s., Dec. = — 51° 10′ for the equinox 1927.0; the error of which is not greater than 3 minutes of great circle. The other observation—Dec. 6.6715 G.M.T., was similarly reduced by Dr. Adams, who gave for the position at that time R.A. = 16h. 35m. 35s., Dec. = —49° 14.3′ for the equinox 1928.0. The previous observation reduced to the equinox 1928.0 became R.A. = 16h. 26m. 52s. Dec. = — 51° 9.6′. These were probably the two most reliable early observations, though they were, of course, subject to errors in drawing and in scaling. In general, then, the observations of the comet in 1927 were characterized by the following defects:—

(1) Bad situation.

(1) van Biesbroeck, Prof. G., "Comet Notes," *Popular Astronomy*, Feb. 1928.

(2) Crommelin, Dr. A. C. D., *B.A.A. Journal*, vol. 38 No. 4, pp. 124-125, 1928.

(2) Impossibility of obtaining micrometric measures. These two defects made it most difficult to compute a really satisfactory orbit for the comet from those observations.

At an early date it was thought that this comet might be the very overdue Comet 1846, IV (De Vico), which was expected to return towards the end of 1921. The elements of the orbit of that comet, as computed by Von Hepperger, were

$$\begin{aligned} T &= 1846, \text{ March } 5.552 \text{ Paris Mean Time.} \\ \omega &= 12^\circ\ 53'\ 27'' \\ \Omega &= 77^\circ\ 33'\ 16'' \quad 1846.0 \\ i &= 85^\circ\ 06'\ 27'' \\ q &= 0.66380 \\ e &= 0.96291 \\ \text{Period} &= 75.7 \text{ years.} \end{aligned}$$

The similarity of the planes of the orbits of these two comets, as defined by the inclination to the plane of the ecliptic, and by the longitude of the ascending node, is very remarkable, but it will be seen by inspecting the orbits given below for the comet 1927k, that the dissimilarity in other respects is too great to justify any speculations on the probability of an identity between the two comets.

SPECTROSCOPIC OBSERVATIONS.

At the Lowell Observatory, Dr. V. M. Slipher obtained a long series of high dispersion spectrograms of the comet on December 16th, 17th, 18th, and 19th. On the 16th the spectrum of the comet was the solar spectrum only, indicating that the comet was wholly illuminated by reflected sunlight, and none of the usual comet emission bands, e.g., those at λλ 5635, 5165, 4737, 4715, 4698, 8685, 4382, 4371, 4365, 3914, and 3883, could be seen or photographed. On the 17th, the Sodium lines λλ 5895.93, 5889.97 were bright though not strong, but these continued to increase both in brightness and strength as the comet approached perihelion.

From the shift of the Sodium Emmission lines D1, D2, Dr. Slipher concluded a positive radial velocity — i.e., a velocity of recession from the observer—of 60 miles per second for December 19th, which was almost identical with that indicated by the computed orbits, and was thus a highly satisfactory result.

A copy of the spectrogram taken at the Lowell Observatory at midday on December 19th, which Dr. Slipher has been kind enough to send to me, showed the comet spectrum on a sky spectrum background, together with the Sodium and the Iron spark spectra for comparison. The Sodium D lines were very strong and bright.

It is well known that the metallic lines are strengthened, and the carbon bands weakened, as a comet approaches the sun, and this is the most probable explanation of the absence of the usual carbon bands in the spectrum of this comet.

The comet was also photographed there in red light at midday on several occasions.

A new line of research was undertaken by Mr. Lampland, of the Lowell Observatory, who, with the aid of the 42-inch reflecting telescope, and heat-measuring apparatus, was able to observe the heat radiations of the comet. This is the first time that such measurements have been applied to comets.

THE OBSERVATIONS.

Following is a list of the observations of the positions of the Comet 1927k, covering the whole period of its visibility during 1927. There is, however, one serious gap in the catalogue; not a single observation was obtained between December 10.3507 G.M.T. and December 16.2708 G.M.T. It is thus difficult to interpolate with any great accuracy over the intervening period of six days.

The positions from La Plata, Santiago, Bergedorf, Wien, Sonneberg, and Babelsberg are mainly those published in the *Beobachtungs-Zirkular*. Those from Yerkes, Washington, and Whitin are from *Popular Astronomy* and those from Kodaikanal were published in the *Monthly Notices of the Royal Astronomical Society*. For the New Zealand observations I have to thank the observer, Dr. C. E. Adams, Dominion Astronomer, and for additional observations from the Hamburger Sternwarte (Bergedorf), I have to thank the director, Professor Dr. Schorr.

At discovery, the comet's magnitude was estimated at 3 by Skjellerup; that was on December 3rd. On December 6th, Maristany at La Plata gave the magnitude as 2, and by the 7th its magnitude had increased to 1, at which time the tail was about 3 degrees in length. On December 16th, after the comet had passed out of our southern night skies, it was seen with the unaided naked eye by Dr. H. Worner(3) of the Hanover Flugwetterwarte, about 7 degrees north of the sun, and on the following day, it was seen at the Hamburger Sternwarte, Bergedorf(3), about 8 degrees north of the sun, and having a tail about 3 degrees long. The Bergedorf observers estimated the nucleus to have then been of the 1st magnitude. On the 19th, Muller, of the Potsdam Observatory(3), estimated it to be of the 1st magnitude. At the same time, Hoffmeister, of the Sonneberg Observatory(4), estimated it to be of the 1st magnitude, and gave the length of the tail as about 8 degrees. Dr. Crommelin(5) estimated that the greatest magnitude could not have been much less than - 10, certainly(6) it was not less than —6. By December 21st, the magnitude had dropped(7) to 2.8, and by the 24th(8) it was down to 3 again and getting fainter.

The following is the catalogue of the observations of the comet during December 1927:—

---

(3) *Beobachtungs-Zirkular*, Nr. 43, 1927.
(4) *Boebachtungs-Zirkular* Nr. 44, 1927.
(5) Crommelin, Dr., *Journal, B.A.A.*, vol. 38, Nr. 3, 1928.
(6) *Nature*, 1928, Jan. 21, p. 113.
(7) *Beobachtungs-Zirkular*, Nr. 43, 1927.
(8) Van Biesbroeck, Prof. G., "Comet Notes," *Popular Astronomy*, 1928, February.

COMET 1927k. (Skjellerup)—OBSERVATIONS.

No	G M T Dec 1927	Right Ascension H	M	S	South Declination °	′	Place	Observer	Remarks
1.	3.7292	16	12	12	53	57	Melbourne	Skjellerup	First recorded position.
2.	4.6389	16	17		52	43	New Plymouth	Rhind	Sextant observation.
3.	5.6458	16	27		51	10	Auckland	McIntosh	Reduced by Dr. Crommelin (1927.0)
4.	6.0250	16	27		50	00	La Plata	Maristany	
5.	6.6715	16	35	35	49	14 3	Auckland	McIntosh	Reduced by Dr. Adams (1928.0).
6.	7.8586	16	41	17	47	48 2	Santiago	Castro	
7.	8.3556	16	49	32	45	34	Wellington	Dr. Adams	9-inch telescope circle readings.
8.	9.3542	16	56	35	43	03	Wellington	Dr Adams	9-inch telescope circle readings.
9.	10.3507	17	04	11	40	19	Wellington	Dr. Adams	9-inch telescope circle readings.
10.	16.2708	17	37		20	17	Kodaikanal	Chidambara Aiyar	
11.	17.1945	17	43		17	20	Kodaikanal	Chidambara Aiyar	
12.	17.4866	17	40.1		16	35	Bergedorf	Schwassmann and Wachmann	Lippart Astrograph.
13.	17.5096	17	40.2		16	32	Bergedorf	Schwassmann and Wachmann	Lippart Astrograph.
14.	17.6264	17	40.4		16	15	Bergedorf	K. Graff	60 cm. Refractor.
15.	17.923	17	47		15	19	Washington	Burton	
16.	18.2389	17	46		14	43	Kodaikanal	Chidambara Aiyar	
17.	18.6174	17	43.1		14	05	Bergedorf	K. Graff	60 cm. Refractor.
18.	18.6309	17	43.2		14	02	Bergedorf	Kruse	26 cm. Equatorial (2 obs.).
19.	18.954	17	44		13	25	Yerkes	Van Biesbroeck and Morgan	

COMET 1927k. (Skjellerup)—OBSERVATIONS.—Continued.

No	G M T Dec 1927	Right Ascension H	M	S	South Declination °	′	Place	Observer.	Remarks.
20.	19.5631	17	45.2		12	40.7	Yerkes	Van Biesbroeck and Morgan	
21.	19.6528	17	40		13	00	Wien	Hepperger	
22.	19.6726	17	45	33	12	35	Sonneberg	Hoffmeister	
23.	20.5512	17	46	58	11	49.5	Yerkes	Van Biesbroeck and Morgan	
24.	20.6324	17	47.2		11	47	Bergedorf	Kruse	26 cm. Equatorial (2 obs.).
25.	20.6496	17	47	11	11	45	Babelsberg	G. Struve	
26.	20.6688	17	47	04	11	48	Sonneberg	Hoffmeister	
27.	20.9492	17	47	41	11	37.7	Yerkes	Van Biesbroeck and Morgan	
28.	21.5474	17	48	43	11	26.8	Yerkes	Van Biesbroeck and Morgan	
29.	21.6354	17	48	55	11	25.5	Babelsberg	G. Struve	
30.	22.5594	17	50	24	11	23.3	Yerkes	Van Biesbroeck and Morgan	
31.	23.5549	17	51	57	11	31.7	Yerkes	Van Biesbroeck and Morgan	
32.	24.532	17	53	50	11	48	Yerkes	Van Biesbroeck	
33.	25.492	17	57		12.1		Whitin Obsy.	Duncan	
34.	27.475	18	00		13.0		Whitin Obsy.	Duncan	

For the purpose of comparing the various orbits which have been suggested, and for investigating with what degree of accuracy they fitted the observations, I plotted these observations, and from the graph so obtained, scaled off approximate positions at 8 day intervals from December 4th to December 28th.

Approximate Positions Scaled from Diagram.

Date.	R A.	Dec.
December, 1927.		
4.0	16h. 14m.	— 53° 40′
12.0	17h. 15m.	— 35° 30′
20.0	17h. 47m.	— 12° 10′
28.0	18h. 00m.	— 13° 20′

These positions were only approximate, but it should be borne in mind that the original observations were liable to errors of 0.1 minute in right ascension and of 3 or 4 minutes or more in declination.

THE ORBIT.

(*a*) The first orbit published was that by Wood, of Johannesburg, as follows:—

$$\begin{aligned} T &= 1927,\ \text{Dec. } 1.192 \text{ G.M.T.} \\ \omega &= 323^\circ\ 29' \\ \Omega &= 79^\circ\ 20' \\ i &= 72^\circ\ 10' \\ q &= 0.6058 \end{aligned} \quad \left.\begin{matrix} \\ \\ \\ \end{matrix}\right\} 1927.0$$

This orbit was necessarily computed from a very short arc, as it was issued from Copenhagen on December 12th. The above elements gave rise to the following Ephemeris:—

Date.	R A.	Dec.
December, 1927.		
4.0	16h. 14m.	— 53° 50′
10.0	17h. 3m.	— 41° 10′
22.0	18h. 40m.	+ 14° 8′
30.0	19h. 23m.	+ 36° 52′

It will be seen immediately that although the early observations were satisfied by this, the errors soon became exceedingly great.

The next orbit published was by Dawson, of La Plata, who gave the following elements:—

$$\begin{aligned} T &= 1927,\ \text{Dec. } 18.200 \text{ G.M.T.} \\ \omega &= 20^\circ\ 58' \\ \Omega &= 78^\circ\ 43' \\ i &= 82^\circ\ 41' \\ q &= 0.3230 \end{aligned} \quad \left.\begin{matrix} \\ \\ \end{matrix}\right\} 1927.0$$

This was also from a short arc, for it was distributed from Copenhagen on December 19th. From these elements, the following Ephemeris was constructed:—

Date.	R.A.	Dec
December, 1927		
4.0	16h. 15m.	— 53° 35′
10.0	17h. 3m.	— 41° 21′
20.0	17h. 54m.	— 8° 59′
28.0	18h. 11m.	— 1° 40′

This was a little nearer the truth than the orbit by Wood, but although the early observations were satisfied, the errors were far too great to give a satisfactory agreement with the later observations.

An orbit published about the same date by myself from three observations by Dr. Adams on the 8th, 9th, and 10th December, and which was admittedely in error, was:—

$$\begin{aligned} T &= 1927,\ \text{Nov. } 28.403\ \text{G.M.T.} \\ \omega &= 315^\circ\ 47' \\ \Omega &= 80^\circ\ 20' \\ i &= 67^\circ\ 44' \\ q &= 0.5963 \end{aligned} \quad \left.\begin{matrix}\\ \\ \\ \\ \end{matrix}\right\} 1927.0$$

It satisfied the original observations in some measure (e.g., for Dec. 4.0, R.A. 16h. 20m., Dec. = — 53° 1′), but the errors soon became too great.

These three preliminary orbits suffered from three bad faults.

(1) They were computed from short arcs. This is the unavoidable defect of any preliminary orbit.

(2) They differed considerably among themselves, chiefly in—
(a) Date of Perihelion,
(b) Argument of Perihelion,
(c) Perihelion distance.

(3) They entirely failed to represent in any measure the later observations.

(*b*) The next orbit published was by Dr. Crommelin[9] and was a vast improvement on any previous one. His elements were as follows:—

$$\begin{aligned} T &= 1927,\ \text{Dec. } 18.61\ \text{G.M.T.} \\ \omega &= 42^\circ\ 56' \\ \Omega &= 81^\circ\ 19' \\ i &= 83^\circ\ 52' \\ q &= 0.1822 \end{aligned} \quad \left.\begin{matrix}\\ \\ \\ \\ \end{matrix}\right\} 1927.0$$

These elements gave the following Ephemeris, which was in very much better agreement with observation than were any of the previously published orbits:—

(9) Crommelin, Dr. A. C. D., *Journal B.A.A.*, vol. 38. Nr. 3.

Date.	R.A.	Dec.
December, 1927.		
4.0	16h. 12m.	— 54° 15′
12.0	17h. 10m.	— 37° 8′
20.0	17h. 45m.	— 12° 32′
28.0	17h. 57m.	— 11° 30′

The greatest weakness about this was the fact that the declinations were too great in the early part, and too small in the latter part. This, however, was the first orbit to represent the whole series of observations with any degree of accuracy at all.

(*c*) As was to be expected, the elements computed from longer arcs gave much more satisfactory results.

Van Biesbroeck computed the following elements from observations made at Yerkes Observatory, Williams Bay[10]:—

$$\begin{aligned} T &= 1927,\ \text{December } 18.360 \text{ G.M.T.} \\ \left.\begin{aligned} \omega &= 48^\circ\ 38' \\ \Omega &= 77^\circ\ 12' \\ i &= 84^\circ\ 48' \end{aligned}\right\} &\ 1927.0 \\ q &= 0.1793. \end{aligned}$$

For an Ephemeris using the method of Dr. Adams and Dr. Crommelin[11] these elements gave:—

$$\begin{aligned} x &= +\ 0.01436\ (1 - \tan^2 \tfrac{v}{2}) - 0.08057\ \tan \tfrac{v}{2} \\ y &= +\ 0.05521\ (1 - \tan^2 \tfrac{v}{2}) - 0.33032\ \tan \tfrac{v}{2} \\ z &= +\ 0.16998\ (1 - \tan^2 \tfrac{v}{2}) + 0.11407\ \tan \tfrac{v}{2} \end{aligned}$$

whence the following Ephemeris:—

Date	R.A.	Dec.
December, 1927		
4.0	16h. 13m.	— 54° 9′
12.0	17h. 15m.	— 35° 4′
20.0	17h. 46m.	— 12° 14′
28.0	18h. 00m.	— 13° 15′

which was in a fairly good agreement with the observed positions.

A second orbit was computed by Dr. Crommelin[12] using observations from December 3rd to December 20th, and was as follows:—

$$\begin{aligned} T &= 1927,\ \text{Dec. } 18.008 \text{ G.M.T.} \\ \left.\begin{aligned} \omega &= 46^\circ\ 9.7' \\ \Omega &= 76^\circ\ 25.2' \\ i &= 85^\circ\ 27.2' \end{aligned}\right\} &\ 1927.0 \\ q &= 0.1724 \end{aligned}$$

(10) Van Biesbroeck, Prof. G., "Comet Notes," *Popular Astronomy*, 1928, February.

(11) Adams, Dr. C. E., "Calculation of a Comet's Co-ordinates," *Journal B.A.A.*, vol. 32, Nr. 6, p. 231, and Crommelin, Dr., "Simplification of the Computation of an Ephemeris of a Comet moving in a Parabola," *ibid*, Nr. 8, p. 305.

(12) Crommelin, Dr. A. C. D., *Journal B.A.A.*, vol. 38, Nr. 4 (1928), p. 125, also *Nature*, 1928, January 21, p. 113.

For an Ephemeris these gave:—

$$x = +\ 0.01846\ (1 - \tan^2 \tfrac{v}{2}) - 0.07680 \tan \tfrac{v}{2}$$
$$y = +\ 0.05932\ (1 - \tan^2 \tfrac{v}{2}) - 0.31241 \tan \tfrac{v}{2}$$
$$z = +\ 0.16081\ (1 - \tan^2 \tfrac{v}{2}) + 0.12406 \tan \tfrac{v}{2}$$

from which the following Ephemeris:—

Date	R A	Dec.
December, 1927.		
4.0	16h. 14m.	— 53° 34′
12.0	17h. 16m.	— 35° 12′
20.0	17h. 46m.	— 12° 15′
28.0	17h. 59m.	— 13° 17′

This was in good agreement with the observed places; in better agreement in fact than are the calculated places from van Biesbroeck's orbit. For convenience, this orbit will be referred to as "Crommelin II," to distinguish it from Crommelin's preliminary orbit.

A third orbit was computed by the writer from observations over the period December 8th to December 24th. This will be referred to as "Glover II," as distinct from the preliminary orbit by the same computer. The elements of this were:—

$$T = 1927,\ \text{Dec. } 18.390\ \text{G.M.T.}$$
$$\left.\begin{aligned} \omega &= 47^\circ\ 48' \\ \Omega &= 77^\circ\ 49' \\ i &= 84^\circ\ 06' \end{aligned}\right\}\ 1927.0$$
$$q = 0.1750$$

from which, for an Ephemeris:—

$$x = +\ 0.01178\ (1 - \tan^2 \tfrac{v}{2}) - 0.07834 \tan \tfrac{v}{2}$$
$$y = +\ 0.05672\ (1 - \tan^2 \tfrac{v}{2}) - 0.32086 \tan \tfrac{v}{2}$$
$$z = +0.16513\ (1 - \tan^2 \tfrac{v}{2}) + 0.11581 \tan \tfrac{v}{2}$$

which gave the following:—

Date	R A	Dec
December, 1927		
4.0	16h. 15m.	— 54° 18′
12.0	17h. 15m.	— 36° 43′
20.0	17h. 46m.	— 12° 29′
28.0	18h. 00m.	— 13° 26′

These values did not fit the observations so well as did those from the orbits by van Biesbroeck and Crommelin.

A comparison of the orbits was made by considering the O-C residuals of the places computed from each. These residuals were as follows, the sign of the declination being taken into account:—

Orbit	Dec. 4 0 O-C in		Dec. 12 0 O-C in		Dec. 20.0 O-C in		Dec. 28 0 O-C in	
	R.A. m.	Dec ′	R.A. m.	Dec. ′	R.A. m	Dec. ′	R.A. m.	Dec. ′
Crommelin II .	—1	— 6	+1	—18	+1	0	—1	—3
van Biesbroeck	+1	+25	0	—26	+1	— 1	0	—5
Glover II	—1	+38	0	+73	+1	+14	0	+6

The outstanding feature of these residuals was that for the declinations they were unduly large. From the nature of the observations one would not expect a remarkably good result, for in declination the circle readings could be as much as 5 minutes in error. It was evident, though, that the elements were still in need of adjustment in order to make the agreement in declination more satisfactory. The residuals for each individual orbit were then considered.

1. Glover II.—The residuals in right ascension were quite satisfactory compared with those for the two other orbits, but in declination the residuals were much greater than is the case for Crommelin's orbit or van Biesbroeck's orbit. We thus disposed of this orbit as being the least satisfactory of the three.

2. van Biesbroeck.—With regard to the right ascension residuals, the same remarks as for the preceding applied. With regard to the residuals in declination, these were a considerable improvement on those from the preceding, but were not so good as those from Crommelin's orbit.

3. Crommelin II.—The residuals in right ascension were as satisfactory as those from the two preceding cases, when we considered that the value scaled from the graph for December 12.0 was interpolated in an interval of 6 days, throughout which recorded observations were entirely lacking, and that for December 28.0 was extrapolated. Further, the residuals in declination, although by no means good, were decidedly better than in either of the two preceding cases.

It was justifiable then to rule out the orbits by van Biesbroeck and by Glover, as being the least satisfactory, and in retaining Crommelin's second orbit as being, though not good, at least the best orbit published up till that time.

I should like here to appeal to amateur astronomers in New Zealand to take up computational work, as it is an invaluable asset to be able to get out an approximate orbit, or ephemeris, instead of having to wait for one to come from England or Copenhagen. The

standard English(13) and foreign(14) treatises may be difficult, but I recommend to the amateur, with the confidence of experience, the remarkably easy method of Merton(15). Apart from Merton's paper, one requires only a set of 7 figure logarithmic and trigonometric tables and a *Nautical Almanac*. Dr. Merton's method is equally well adapted to both machine and logarithmic calculation. The work is not difficult, in spite of the popular superstition to the contrary.

In New Zealand the computing of Ephemerides and Orbits is left in the hands of about two people; a highly unsatisfactory state of affairs.

Returning to our consideration of the orbit of the Comet 1927k. I have shown that the best set of elements computed during the early stages of the investigation was that by Dr. Crommelin, and I give below the extended Ephemeris based on those elements.

THE EXTENDED EPHEMERIS.

The following Ephemeris is based on Crommelin's second set of elements, and proved to be a fair representation of the course of the comet.

Date	R A	Dec
1928		
Jan. 24.0	18h. 37m.	— 22° 35′
Feb. 9.0	18h. 54m.	— 26° 20′
Feb. 25.0	19h. 6m.	— 29° 46′
Mch. 12.0	19h. 13m.	— 33° 10′
Mch. 28.0	19h. 12m.	— 37° 0′
May 31.0	17h. 18m.	— 50° 23′

After the bulk of this paper had been prepared, a considerable amount of information in the nature of additional observations and orbital elements came to hand.

(13) Plummer, H. C., 1918, *Dynamical Astronomy*, Cambridge University Press.
Watson, J. C., 1900, *Theoretical Astronomy*, Philadelphia, Lippincott Co.
Moulton, F. R., 1914, *Celestial Mechanics*, New York, Macmillan Co.

(14) Bauschinger, Julius, *Bahnbestimmung der Himmelskörper*, Leipzig, W. Engelmann, Zweite Auflage, 1928.
Valentiner, W., *Handwörterbuch der Astronomie*, Leipzig: J. A. Barth, 1902 (Band 4) and Breslau, E. Trewendt, 1901 (Bände 1, 2, 3).
von Oppolzer, Th., *Lehrbuch zur Bahnbestimmung der Kometen und Planeten*. Leipzig, W. Engelmann, 1882. There is a French edition *Traité de la Détermination des Orbites des Comètes et des Planètes*, Paris, Gauthier-Villars, 1886.
Klinkerfues, W., *Theoretischen Astronomie* Braunschweig, F. Vieweg, 1912.

(15) Merton, G., *A Modification of Gauss's Method for the Determination of Orbits*, M.N.R.A.S., vol. 85, Nr. 8.

The additional observations were:—

Date.	Right Ascension.			South Declination.			Observatory.
December, 1927.	h.	m.	s.	°	′	″	
6.106	16	20	30	50	22		Johannesburg
8.3279	16	48	28	45	37	12	La Plata
9.121	16	55	48	43	44		Johannesburg
21.5986	17	48	48	11	24		Turku
21.6118	17	48	52	11	25	54	Turku*
22.2910	17	50	6	11	21		Turku
25.2681	17	55	18	12	2		Turku
February, 1928.							
10.12425	18	57	36.90	26	47	36.2	Cape†
11.08398	18	58	31.01	27	00	13.3	Johannesburg†
11.11875	18	58	32.77	27	00	43.7	Cape†
13.12091	19	00	21.70	27	26	47.9	Cape†
23.32042	19	06	40.8	29	40	23	La Plata§
24.09735	19	08	59.28	29	47	38.1	Johannesburg†
29.11940	19	12	06.07	30	52	12.0	Cape†
March, 1928.							
3.30480	19	11	59.0	31	36	39	La Plata§
21.30243	19	16	25.6	35	44	57	La Plata§

Three additional orbits have come from America (see *L.O. Bull.* 395, and *Publ. A.S.P.*, XL, 233) and are given below.

1.

$$\begin{array}{ll} T \ldots\ldots & \text{1927 Dec. 19.363 G.M.T.} \\ \omega \ldots\ldots & 57^\circ\ 26' \\ \Omega \ldots\ldots & 73^\circ\ 33' \\ i \ldots\ldots & 83^\circ\ \ 5' \\ q \ldots\ldots & 0.1924 \end{array} \quad \left.\begin{array}{l} \\ \\ \\ \end{array}\right\} 1927.0$$

Computer: Dr. Smiley.

Reference: *Publ. A.S.P.* XL, 233.

This orbit was not a very satisfactory one, and gave poor residuals.

2.

$$\begin{array}{ll} T \ldots\ldots & \text{1927 Dec. 17.7.} \\ \omega \ldots\ldots & 31^\circ\ 24' \\ \Omega \ldots\ldots & 81^\circ\ 24' \\ i \ldots\ldots & 85^\circ\ 48' \\ q \ldots\ldots & 0.173 \end{array} \quad \left.\begin{array}{l} \\ \\ \\ \end{array}\right\} 1927.0$$

Computer: Makemson.

Reference: *Publ. A.S.P.*, XL 233.

This was not a satisfactory orbit. The value of ω was too small, and of Ω too large. The residuals were unsatisfactory.

*Sextant observation.
†Referred to mean equinox 1928.0.
§Referred to mean equinox 1900.0.

3.

T	1927 Dec. 18.1162 G.M.T.			
ω	46° 40′ 46″	1928.0	46° 40′ 46″	1927.0
Ω	77° 13′ 32″	1928.0	77° 12′ 42″	1927.0
i	85° 12′ 41″	1928.0	85° 12′ 41″	1927.0
q	0.17524			

Computers: Mayall and Whipple.

Reference: *L.O.B.* 395 and *Publ. A.S.P.* XL, 233.

This was a fairly good orbit giving reasonable residuals, but it was not as good as a more recent orbit computed by Dr. Crommelin given below:—

T	1927 Dec. 18.1671 G.M.T.	
ω	47° 8.82′	1927.0
Ω	77° 14.90′	1927.0
i	85° 12.81′	1927.0
q	0.176112	

This orbit was computed from normal places for Dec. 5th and 21st, and with an observation from South Africa on Feb. 11th. It is decidedly the best and most reliable orbit so far obtained. The Gaussian equations for the coordinates are:—

$$
\begin{aligned}
x &= 0.23524\ r \sin\ (v + 157^\circ\ 22.20') \\
y &= 0.97201\ r \sin\ (v + 160^\circ\ \ 8.32') \\
z &= 0.99993\ r \sin\ (v + \ \ 69^\circ\ 59.14')
\end{aligned}
$$

for the mean equinox and equator 1927.0.

Dr. Adams very kindly sent me an Ephemeris by Dr. Crommelin based on the above, from April 25th to May 19th.

G.M.T. 1928	R.A	
Apr. 25.0	18h. 52m. 33s.	— 44° 56′
May 3.0	18h. 38m. 3s.	— 47° 1′
May 11.0	18h. 20m. 12s.	— 48° 51′
May 19.0	17h. 59m. 29s.	— 50° 18′

to which I have added:—

May 31.0	17h. 24m. 26s.	— 52° 21′

For this latter position, the logarithm of the radius-vector was 0.4997 and the logarithm of the geocentric distance was 0.3315.

From the approximate formula(16) connecting the brightness of a comet at two times when radii vectores and geocentric distances are known, I found that in May the comet should have been of about the 8th or 9th magnitude, at which time it was in the constellation Corona Australis.

A comparison with the observed places given above shows that the latest elements computed by Dr. Crommelin (see the last of the

(16) Traylor, M. C., *Popular Astronomy*, 86, 342, 1901.

third lot of additional orbits preceding) are a very good representation of the movements of the comet, and indeed the most accurate yet calculated.

This description of the attempts to define the motions of the Comet 1927k would be incomplete without reference to an orbit which did not reach me until after this paper had been read. It is by Dr. Crommelin[17] and represents the observational data from 1927, Dec. 6 to 1928 March 31 within 2 seconds of arc, and is thus the most accurate description of the comet's motion yet obtained. The elements of this orbit are as follow:—

$$
\begin{aligned}
T &= 1927 \text{ Dec. } 18.18340 \text{ G.M.T.} \\
\left.\begin{aligned}
\omega &= 47^\circ\ 11'\ 13.24'' \\
\Omega &= 77^\circ\ 13'\ 29.62'' \\
i &= 85^\circ\ \ 6'\ 22.01''
\end{aligned}\right\} & \ 1927.0 \\
q &= 0.1763108.
\end{aligned}
$$

The smallness of the residuals from this orbit show that there is practically no sensible deviation from the parabola.

In conclusion, I wish to record my thanks to Dr. C. E. Adams, Dominion Astronomer, who has kept me well supplied with all the latest information from abroad regarding the comet, and who was kind enough to supply me with a copy of a table he is preparing for the solution of Euler's Equation for the parabola, which table is a considerable improvement on the tables by Bauschinger and by Watson, especially when the computing is done on a machine. My thanks are also due to Dr. V. M. Slipher, of the Lowell Observatory, for a photograph and spectrogram of the Comet, to Professor Dr. Schorr, Director of the Hamburger Sternwarte, for a catalogue of the observations made there, to my friend, Prof. C. Coleridge Farr, D.Sc., F.R.S., for reading this paper for me during my unavoidable absence from Christchurch, and to Dr. Hartmann for the La Plata observations.

Christchurch,
May 10th, 1928.

(17) M.N., R.A.S., vol. 88, Nr. 7, May 1928, and Journal B.A.A., vol. Nr. 7, June 1928.

The Male Genitalia of the New Zealand Tortricidae.

By ALFRED PHILPOTT, Hon. Research Student in Lepidoptera,
Cawthron Institute, Nelson.

[*Read before the Nelson Philosophical Society, 4th July, 1928; received by Editor, 6th July, 1928; issued separately, 16th November, 1928.*]

THE named Tortricidae of the world probably now comprise between 1,300 and 1,400 species. To this total New Zealand contributes rather more than 100 forms, all but a few of the 112 described species on our list being endemic. Taking the number of known (named) insects in the world as 471,000 (see Tillyard, *Insects of Australia and New Zealand*, p. 8), we find that the Lepidoptera represent about 19.5 per cent. of that total. The number of Tortricidae now listed being set down as 1,350 (Meyrick, *Genera Insectorum*, 1913, tabulates 1,031 species) gives the per centage of this family to the whole of the Order as about 1.5 The proportion of New Zealand Tortricids to the total New Zealand Lepidoptera is about 8 per cent., thus showing that the family is quite well represented specifically. Of the 15 genera found in New Zealand seven are endemic, namely, *Ochetarcha* Meyrick, *Eurythecta* Meyrick, *Ascerodes* Meyrick, *Epalxiphora* Meyrick, *Gelophaula* Meyrick, *Ecclitica* Meyrick, and *Philocryptica* Meyrick, three, *Capua* Stephens, *Tortrix* Linnaeus and *Cnephasia* Curtis, are practically cosmopolitan, and the remainder chiefly of Australian and New Zealand distribution.

During the course of the present study it has become apparent that several species have been heretofore misplaced generically; the necessary nomenclatural changes will be indicated in the body of the paper and will be more formally dealt with in a descriptive paper appearing elsewhere in this volume.

GENITALIA CHARACTERS OF THE FAMILY.

The most recent text-book dealing with the Lepidoptera (Tillyard, *The Insects of Australia and New Zealand*, 1926) treats the Tortricid groups as forming a section of the super-family Tineoidea. The male genitalia of the Tortricids are, however, of so different a type from those of the Tineoids proper that there seems to be sufficient reason for bestowing on them super-family rank. The development of the socii and transtilla, with the hinged aedeagus, are the chief characters which serve to distinguish the Tortricids, though with the exception of the last mentioned these are not invariably present. The eighth segment is normally unmodified, but occasionally, as in *Ascerodes*, the tergite may be clothed dorsally with long hair-scales which project above the tegumen. The tegumen is usually moderately broad and does not fuse with the vinculum, but connects membranously with the upper basal angles of the harpes, its lateral extremities being suddenly narrowed and slightly incurved. The uncus is small to moderately large, thus offering a distinction from

the Euscosmidae, where this organ is usually absent or very weakly developed. In the Tortricidae the part is always more or less bent downwards, sometimes almost at right angles; frequently it is dilated apically and more or less indented; occasionally it is so expanded laterally as to become battledore-shaped. Almost invariably the lateral apical areas of the uncus are clothed with short stiff hairs beneath. The socii are normally well developed though occasionally vestigial. They are most commonly long, narrow, and somewhat drooping, but in some species they form rounded or reniform plates. They are always covered with long, thin, backwardly-directed hair. The gnathos is, for the most part, uniform in shape, being more or less foot-like from a lateral view, an appearance caused by the pair of arms meeting on the meson, fusing, and turning sharply caudad. The aedeagus is generally fairly stout and more or less curved or bent; the anellus projects beneath and connects with the rounded or shield-shaped juxta, thus forming the cardinate or "hinged" aedeagus of Pierce (*The Genitalia of the British Tortricidae*, xviii). Cornuti are frequently present, but as Pierce states (op. cit., xx) that these are in some instances deciduous, care must be exercised in using them as a systematic character. Further, as they are attached to the penis (apical portion of the ductus ejaculatorius) which is capable of movement within the aedeagus, the position of cornuti as shown in figures must not be given much weight. The orifice of the aedeagus is not usually completely apical, but extends for some distance down the right side. The harpes are invariably broad and usually simple; the sacculus is nearly always defined, but is seldom apically free except for a very short distance. The outer surface is usually thickly scaled and the inner surface clothed more or less with rather weak hair; stout spines are not present. The transtilla is not here an extension of the costal angle of the harpe, but is composed of a pair of chitinous processes arising just caudad of it. These expand into angular plates which bear series of small spines and project above the aedeagus, meeting on the meson and being either membranously connected or completely fused there. The vinculum is greatly reduced, being only a narrow strip of chitin with the saccus undeveloped; the arms do not usually meet the arms of the tegumen, but are more or less firmly attached to the bases of the harpes. A peculiar development occurs in some genera, the basal part of the vinculum being dechitinised and the lateral pieces connected by membrane only. Pierce (op. cit. xviii) notes the same structure in certain Phaloniidae and suggests that the condition indicates that the vinculum is "really a development of the two projections which hinge the body segments together and which are so conspicuously developed in the anal segments of the female." It is not clear what "projections" are here referred to, but to the writer it seems certain that the vinculum is the ninth sternite and that the "arms" are simply the lateral portions thereof, these being greatly narrowed and not fused to the tegumen (9th tergite), while the ventral area has become membranous.

GENITALIA CHARACTERS OF THE GENERA AND SPECIES.

Ochetarcha Meyrick.

Monotypic. Endemic. Only a few examples of this interesting form have been taken and I have been unable to examine the genitalia.

Cnephasia Curtis. (Figs. 1 to 7.)

A large genus; practically cosmopolitan. Ten New Zealand species have been described, of which seven have been available for dissection.

Tegumen small to moderate; uncus usually thin and sharply bent, never, except in *latomana,* dilated apically. Socii small and narrow (in *latomana* vestigial) or dilated into a rounded plate covered with long hair. Gnathos normal, porrect, except in *imbriferana,* where it is reduced and merges with the anal tube. Aedeagus short to moderately long, moderately curved or sinuate, pointed or subtruncate. Anellus and juxta normal. Harpes broad, not much narrowed apically; transtilla a plain or lobed band bearing minute spines. Vinculum much reduced, short and narrow.

Considered on the genitalia characters, the species do not form a closely related assemblage. *Latomana, imbriferana* and *microbathra* are all more or less isolated, *jactatana* and *incessana* form a more nearly related pair, while *sphenias* and *fastigata* (formerly placed in *Tortrix*) exhibit more affinity than any of the others.

KEY TO THE SPECIES OF *CNEPHASIA*.

1	Socii large, rounded or apically dilated	2.
	Socii small, vestigial, finger-like or short and rounded	4.
2.	Uncus very narrow, pointed; socii covered with dense long hairs	3.
	Uncus much broader, apex rounded; socii moderately haired	*microbathra*
3.	Harpes pointed at apex	*jactatana.*
	Harpes subtruncate at apex	*incessana.*
4.	Uncus very narrow on dorsal view; socii very short but broad	*imbriferana.*
	Uncus moderate or very broad on dorsal view	5.
5.	Uncus very broad; socii vestigial	*latomana.*
	Uncus moderately broad	6.
6.	Socii very short; juxta with apices rather produced; lobes of transtilla rounded	*sphenias.*
	Socii moderately long; juxta with apices not produced; lobes of transtilla somewhat angular	*fastigata.*

Harmologa Meyrick. (Figs. 8 to 17.)

A rather small genus, most numerous in New Zealand, but with a few Australian and Indian species and one in North America. Thirteen New Zealand species have been described, ten of which are here dealt with.

Tegumen moderate to broad; uncus moderate to very broad, apex frequently more or less indented. Socii generally small or vestigial. Gnathos normal or with projections at " heel." Aedeagus curved or bent, usually swollen basally, frequently with a small hook on margin of orifice. Anellus and juxta normal. Harpes broad, hardly

narrowed apically; sacculus extending to near apex of harpe, tip usually shortly free; transtilla usually rather weak, seldom fused into complete band. Vinculum weak and narrow.

KEY TO SPECIES OF *HARMOLOGA*.

1.	Socii vestigial or absent	2.
	Socii more or less developed	3.
2.	Socii absent; gnathos basally expanded into a pair of broad rounded plates	*tenebrosa.*
	Socii vestigial; gnathos with cephalic process	*oblongana.*
3.	Apex of uncus not indented	4.
	Apex of uncus more or less indented	6.
4.	Uncus broad, subtruncate or rounded apically	5.
	Uncus rather narrow, rounded apically	*sanguinea.*
5.	Uncus gradually dilated to apex; transtilla fused; aedeagus without barb	*festiva.*
	Uncus more strongly dilated at apex; transtilla not fused; aedeagus with strong barb towards apex on right	*reticularis.*
6.	Uncus strongly constricted basally	*petrias.*
	Uncus not strongly constricted basally	7.
7.	Uncus with apex deeply indented, not constricted basally	*amplexana.*
	Uncus with apex not deeply indented, slightly constricted basally	8.
8.	Socii very small; aedeagus much swollen basally	*columella.*
	Socii moderately large; aedeagus not swollen basally	9.
9.	Aedeagus sinuate, moderately long, with few short cornuti; socii very narrow	*scoliastis.*
	Aedeagus rather short, not sinuate, with bunch of very long and stout cornuti; socii broader	*pontifica.*

Gelophaula Meyrick. (Figs. 18 to 22.)

Endemic. A subalpine genus of which eight species have been described; four of these are here dealt with, together with a new species described elsewhere in this volume. There is little difficulty in recognizing members of this group, but several of the different forms tend to run into each other, making specific determination by superficial characters no easy matter. Nor do the genitalia offer a great deal of assistance, the organs being remarkably uniform and the points of distinction slight and easily overlooked.

Tegumen broad; uncus broad, roundly dilated apically. Socii short, narrow. Gnathos well developed, normal in shape. Aedeagus stout, regularly curved, not tapered apically or swollen basally. Anellus and juxta normal. Harpes very broad, usually narrowed towards apex; sacculus well developed, reaching to about $\frac{4}{5}$, where the apex is shortly free; transtilla normal. Vinculum narrow, weak.

KEY TO THE SPECIES OF *GELOPHAULA*.

1.	Aedeagus with "keel" at base	*tributaria.*
	Aedeagus without "keel"	2.
2.	Aedeagus with apical hook or barb	3.
	Aedeagus without apical hook or barb	4.

3. Uncus rather strongly dilated apically; ventral margin of harpe strongly rounded . .. . *trisculca.*
Uncus less dilated apically; ventral margin or harpe less strongly rounded .... *siraea.*
4. Harpes with apex narrow and rounded ... . *palliata.*
Harpes with apex wider and subtruncate ... .. . *n. sp.*

Ctenopseustis Meyrick. (Fig. 23.)

A genus containing only two species, one in New Zealand and the other in South America.

Tegumen broad; uncus narrow, spoon-shaped. Socii narrow. Gnathos normal. Aedeagus curved, base not swollen, a dense bundle of long cornuti occupying almost entire length. Anellus normal. Juxta a rounded plate with apex deeply emarginate. Harpes broad, oblong; transtilla normal in structure but small. Vinculum very narrow and weak.

Epalxiphora Meyrick. (Fig. 24.)

Monotypic. Endemic.

Tegumen small, narrow; uncus short, narrow, not much curved, with rather long hair above. Socii long, broad basally thence narrow, sinuate. Gnathos weak, slightly upcurved, apex acute. Aedeagus stout, short, pistol-shaped, pointed and with a dense bunch of long, stout cornuti, a small hook near apex on right. Anellus normal. Juxta broadly rounded beneath, divided into two lobes apically. Harpes broad, irregularly tapered to rather narrow apex; sacculus strong, extending to about $\frac{4}{5}$, where it ends in free rounded point; a patch of dense hair in centre towards base. Vinculum small and weak.

Ecclitica Meyrick. (Figs. 25 and 26.)

A small endemic genus containing two species. On a consideration of all the characters I have removed *incendiaria* Meyr. to *Tortrix* and placed *torogramma* (formerly under *Tortrix*) in this genus. It seems improbable that two species exhibiting such close resemblance in genitalia characters as *torogramma* and *hemiclista* should not be congeneric and, on the other hand, that *incendiaria* should belong to *Ecclitica* while showing no affinity to the genitalia characters of the type species, but in this regard much more closely approaching *Tortrix*.

Tegumen moderate; uncus narrow or of moderate breadth, pointed. Socii very small. Gnathos strong, deeply cleft horizontally on meson. Aedeagus long, thin or moderately stout, pointed. Juxta shield-shaped, upper angles more or less produced. Harpes broad, slightly narrowed apically, sacculus well developed; transtilla normal. Vinculum weak.

KEY TO THE SPECIES OF *ECCLITICA*.

Uncus narrow, not constricted basally, apex blunt-pointed; aedeagus rather stout; harpes broad, sacculus shortly free apically .... *torogramma.*
Uncus moderately broad, constricted basally, apex produced; aedeagus thin, sinuate; harpes moderately broad, sacculus apically produced as a free lobe directed obliquely across harpe .... *hemiclista.*

Philocryptica Meyrick. (Fig. 27.)

Monotypic. Endemic. Apparently the example on which this genus was founded was of abnormal venation as 4 and 5 are stated to be short-stalked. This character, however, does not hold in any of the specimens (4) which I have examined, 4 and 5 being separate in origin, though 4 is nearer to 5 than to 3. But apart from the venation the genus seems to be a valid one, characterized by the form of the palpi and the strong double posterior thoracic crest. The genitalia are of the same type as *Harmologa*.

Tegumen moderately broad; uncus broad, hardly dilated apically, apex subtruncate. Socii long, narrow. Gnathos normal. Aedeagus rather long, moderately stout, bent, a small barb on orifice near apex. Juxta angular, apex lobed. Harpes rather broad, slightly tapered, apex subtruncate; sacculus to about $\frac{3}{4}$, apex shortly free; transtilla normal. Vinculum narrow, weak.

Ascerodes Meyrick. (Fig. 28.)

Monotypic. Endemic.

Eighth tergite clothed dorsally with long hair which projects above tegumen. Tegumen broad; uncus very broad, slightly dilated apically, apex subtruncate and slightly indented. Socii vestigial, represented by a tuft of hair on a minute process. Gnathos normal. Aedeagus small, curved, base not swollen. Juxta angular, divided above into a pair of large lobes. Harpes broad, slightly tapered, apex evenly rounded; sacculus reaching to about $\frac{1}{2}$, tip free; transtilla a simple very narrow band. Vinculum short, weak.

Epichorista Meyrick. (Figs. 29 to 40.)

A moderate genus, "chiefly characteristic of Australia, New Zealand, and South Africa, but one Indian species is known and probably others will be discovered, India being presumably the place of origin." (Meyrick). Thirteen New Zealand species have been described, twelve of which have been available for dissection.

Tegumen narrow to moderately broad; uncus narrow to broad. Socii usually developed, narrow or moderate. Gnathos usually normal. Aedeagus usually rather slender, curved or bent. Anellus and juxta normal. Harpes broad, rather short; transtilla seldom fused. Vinculum very small.

KEY TO THE SPECIES OF *EPICHORISTA*.

1. Gnathos bent rectangularly upwards on meson and continued as a long sinuate process . .	*abdita.*
Gnathos not so formed	2.
2. Apex of uncus rounded .	3.
Apex of uncus indented	8.
3. Socii very short and narrow	*speciosa.*
Socii moderate or long	4.
4. Uncus broadly lanceolate; aedeagus with 2 or 3 cornuti occupying more than half the length of the organ	*persecta.*
Uncus not lanceolate; aedeagus without long cornuti	5.
5. Harpes hardly tapered; apex subtruncate	6.
Harpes considerably narrowed apically; apex rounded	*allogama.*

6. Uncus strongly dilated apically; juxta more or less angular	7.
Uncus slightly dilated apically; juxta rounded	*emphanes.*
7. Aedeagus roundly swollen at base, apex rounded	*siriana.*
Aedeagus not roundly swollen at base; apex obliquely pointed	*elephantina.*
8. Uncus very broad, slightly constricted basally	*fraudulenta.*
Uncus not broad	9.
9. Uncus much dilated apically	10.
Uncus hardly dilated apically	11.
10. Aedeagus tapered apically	*aspistana.*
Aedeagus much dilated apically	*hemionana.*
11. Aedeagus long and acute; harpes with lower margin roundly dilated near base	*eribola.*
Aedeagus of normal length, blunt at apex; harpes normal	*zatrophana.*

Eurythecta Meyrick. (Figs. 41 to 46.)

Endemic. There are 6 species, all of which have been examined. On the characters of the genitalia the genus falls into two well-defined groups, each comprising three species. This division, however, does not agree with that indicated by the presence or absence of vein 7 in the forewing, there being four species—*robusta, zelaea, eremana,* and *paraloxa*—in which the vein is absent. Three species—*potamias* Meyr., *trimaculata* Philp., and *varia* Philp.—formerly placed in this genus, have been removed to the Eucosmidae.

A. Tegumen broad; uncus broad, spatulate. Socii vestigial or moderate. Gnathos normal. Aedeagus moderately long, pointed, rather contracted basally. Anellus normal. Juxta band-like or shield-shaped, broadly lobed apically. Harpes triangular, densely clothed with very long hair within; sacculus broad, reaching to $\frac{2}{3}$ or $\frac{3}{4}$; transtilla large, irregular, with rather long spines. Vinculum dechitinised on the meson, arms somewhat dilated basally.

B. Tegumen moderate; uncus broad, more or less dilated apically, apex indented. Socii moderate. Gnathos normal. Aedeagus short or moderate, curved. Anellus normal. Juxta shield-shaped, strongly lobed apically. Harpes rather short, broad, apex rounded or subtruncate; sacculus and transtilla normal. Vinculum normal, not dechitinised on meson.

KEY TO SPECIES OF *EURYTHECTA*.

1. Harpes triangular, inner surface with very long caudally-directed hair; vinculum dechitinised on meson	2.
Harpes not triangular, inner surface with short hair directed obliquely towards upper margin; vinculum not dechitinised on meson	4.
2. Socii vestigial	*paraloxa.*
Socii moderate	3.
3. Juxta large, like v-shaped band; apex of harpe rounded	*zelaea.*
Juxta moderate, shield-shaped; apex of harpe pointed	*robusta.*
4. Uncus strongly dilated	5.
Uncus hardly dilated	*eremana.*
5. Harpe with apex evenly rounded; juxta rounded	*loxias.*
Harpe tapering to upper apical angle; juxta angular	*curva.*

Tortrix Linne. (Figs. 47 to 65.)

A large cosmopolitan genus comprising between 200 and 300 species. There are 29 species known from New Zealand, two of which, *T. postvittana* Walk. and *T. indigestana* Meyr., are also found in Australia. As in the preceding genus, the species fall into two groups; these will be dealt with separately.

A. Tegumen small; uncus usually dilated apically. Socii vestigial or absent. Gnathos normal, usually rather evenly curved. Aedeagus moderate, curved, obliquely pointed, base not, or hardly, swollen. Anellus normal. Juxta more or less angular, usually strongly lobed. Harpes more or less triangular, inner surface clothed with long hair directed caudally; sacculus variable, strong or weak, apex free or fused; transtilla normal, not fused. Vinculum normal. On the conjunctiva beyond the eighth segment, towards the ventral surface, is a bunch of long hair which reaches to or beyond the apex of the harpe. When the genitalia are exerted the tightening of the membrane causes these hairs to stand out in a rosette.

B. Tegumen moderate or broad; uncus ranging from narrow to very broad. Socii usually normal, sometimes plate-like, occasionally absent. Gnathos usually normal. Aedeagus usually short, not strongly curved, usually obliquely truncate at apex. Anellus normal. Juxta shield-shaped, angular or rounded, more or less bilobed apically. Harpes broad, more or less oblong, hair on inner surface moderate or short, directed obliquely towards upper margin; sacculus rather short, apex free or fused; transtilla normal, sometimes well fused. Vinculum normal, occasionally dechitinised on meson.

KEY TO THE SPECIES OF *TORTRIX*.

1.	Harpes triangular, hair on inner surface directed caudally; a turf of long hair on conjunctiva beyond eighth segment	2.
	Harpes oblong, hair on inner surface directed towards upper margin; tuft of long hair absent	7.
2.	Uncus narrow at apex	*leucaniana.*
	Uncus broad at apex	3.
3.	Uncus slightly dilated at apex, spatulate; harpes with long finger-like apical process	*postvittana.*
	Uncus strongly dilated at apex; harpes without finger-like process	4.
4.	Harpes with apical portion evenly tapered, long, acute	*argentosa.*
	Harpes with apical portion not evenly tapered to acute point	5.
5.	Uncus battledore-shaped	*subdola.*
	Uncus triangular apically	6.
6.	Harpes with very long hairs; aedeagus scobinate on right	*indigestana.*
	Harpes with hairs of moderate length; aedeagus not scobinate	*maculosa.*
7.	Uncus very broad, apex widely indented; socii absent	*molybditis.*
	Uncus narrow or moderate; socii present	8.
8.	Uncus battledore-shaped; harpes broad, not narrowed apically	*excessana.*
	Uncus not battledore-shaped	9.
9.	Socii moderate to long, narrow	10.
	Socii expanded into rounded plate	16.

10. Uncus with apex deeply indented; juxta almost circular .... *tigris.*
    Uncus with apex rounded .... 11.
11. Uncus narrow .... 12.
    Uncus moderate .... 14.
12. Gnathos with upturned portion laterally compressed to form a broad plate .... *xestodes.*
    Gnathos normal .... 13.
13. Uncus dilated before apex, apex pointed .... *orthropis.*
    Uncus not dilated, apex rounded .... *pictoriana.*
14. Uncus a little dilated then narrowed to apex .... 15.
    Uncus not narrowed to apex .... 16.
15. Uncus with apex subtruncate; socii rather long and densely haired; harpes with apex flatly rounded, angles noticeable .... *spatiosa.*
    Uncus with apex narrower and more rounded; socii shorter and with less hair; harpes evenly rounded, angles not noticeable .... *conditana.*
16. Gnathos short, very thin; uncus circularly expanded apically .... *incendiaria.*
    Gnathos moderately large; uncus gradually expanding to apex .... *charactana.*
17. Uncus with apex rounded .... 18.
    Uncus with apex truncate .... *crypsidora.*
18. Uncus lanceolate with blunt apex .... *flavescens.*
    Uncus finger-like .... *fervida.*

T. inusitata Philp. agrees almost exactly with *T. flavescens* Butl., but in view of the small number of the former which have been captured it is not thought advisable to unite the species at this juncture.

Capua Stephens. (Figs. 66 to 71.)

Practically cosmopolitan. A fairly large genus represented by 8 New Zealand species, one of which, *C. intractana* Walk., is a recent introduction from Australia. The group as here considered is a somewhat incongruous one and probably will ultimately be split up into two or three genera. It therefore seems best to treat each different type separately.

C. semiferana Walk.

Tegumen moderate; uncus short and rather narrow, armed beneath with a dense tuft of short spines and clothed laterally with long hair. Socii weak, somewhat rounded plates. Gnathos normal. Aedeagus not curved, slightly swollen basally, a pair of very large, spear-headed, curved cornuti. Juxta oval with apex deeply emarginate. Harpes rather short, broad, apex rounded; transtilla well developed with spiny apices closely united on meson and an inward hook; sacculus weak, opposite the sacculus the harpe is deeply and widely cleft, leaving a narrow strip of chitin between the sacculus and transtilla. Vinculum normal.

C. cyclobathra Meyr.

Tegumen moderate; uncus strongly curved, very thin. Socii weak, drooping. Gnathos dilated beneath towards meson. Aedeagus long, tapering, a spine-like process projecting obliquely from about $\frac{2}{3}$ and reaching nearly to apex. Juxta a small weak plate. Harpes

moderately broad, rather long, tapering slightly and evenly rounded at apex; sacculus weak; transtilla a rather large well chitinised concave structure fitting round aedeagus and only membranously attached to the harpes; probably the normal processes which have become fused, altered in shape and detached from the harpes. Vinculum normal.

C. intractana Walk.

Tegumen rather narrow; uncus very narrow, slightly dilated apically. Socii broad irregular plates. Gnathos normal, much depressed. Aedeagus short, curved apex expanded and irregularly spinose. Anellus projecting ventrally very little. Juxta kite-shaped. Harpes broad, apex evenly rounded; sacculus short, extending to about ½, apex expanding into inner and outer conical processes; transtilla very slight. Vinculum dechitinised on meson, arms roundly dilated at apex.

C. arcuata Philp.
C. plinthoglypta Meyr.
C. plagiatana Walk.

Tegumen moderate; uncus moderately broad, hardly dilated apically, apex rounded. Socii rather small. Gnathos normal. Aedeagus rather small, bent, "heel" long, small cornuti present. Anellus and juxta normal. Harpes rather short, broad, hardly narrowed apically; sacculus weak, short; transtilla of normal shape but small. Vinculum normal.

KEY TO THE PRECEDING SECTION OF *CAPUA*.

1.	Upper apical angle of harpes pointed	*plinthoglypta.*
	Upper apical angle of harpes rounded	2.
2.	Aedeagus sharply bent; juxta rounded; harpes subtruncate apically	*plagiatana.*
	Aedeagus less sharply bent; juxta angular; harpes more rounded apically	*arcuata.*

Catamacta Meyrick. (Figs. 72 to 74.)

A small genus with 7 New Zealand representatives, only 3 of which have been available for examination.

Tegumen moderately broad; uncus narrow to moderately broad. Socii of normal length, narrow or broad. Gnathos normal. Aedeagus moderately curved, tapering, apex obliquely pointed. Anellus and juxta normal. Harpes broad, oblong, apex subtruncate; sacculus weak, extending to about ½; transtilla normal. Vinculum normal.

KEY TO THE SPECIES OF *CATAMACTA*.

1.	Uncus tapering to narrow apex; socii expanding into broad plate; a patch of long hair on eighth tergite extending over tegumen	*latomana.*
	Uncus not tapering; socii narrow; eighth tergite without long hair	2.
2.	Uncus moderately broad; apex subtruncate; harpes with upper apical angle rectangular	*rureana.*
	Uncus narrow, apex rounded; harpes with upper apical angle rounded	*gavisana.*

Pyrgotis Meyrick. (Figs. 75 to 76.)

A small genus with 3 New Zealand and some Australian species. The rare *P. eudorana* Meyr. has not been available for examination.

Tegumen moderately broad; uncus broad. Socii narrow, rather short. Gnathos normal. Aedeagus rather small, not swollen basally, curved. Anellus and juxta normal. Harpes broad, not narrowed apically; sacculus, reaching to about $\frac{3}{4}$; transtilla normal. Vinculum normal.

KEY TO THE SPECIES OF *PYRGOTIS*.

Uncus gradually expanding to subtruncate apex; aedeagus without barbs above; juxta rounded	*consentiens*.
Uncus not dilated apically; aedeagus with row of minute barbs on upper surface; juxta angular . . .	*pyramidias*.

Proselena Meyrick. (Figs. 77 and 78.)

A small Australian and New Zealand genus; two species have been described from New Zealand.

Tegumen short, moderately broad, remote from vinculum and articulating with the transtillae; socii rather weak, rounded, hairy plates. Gnathos forming a plain narrow band, slightly upturned on the meson. Aedeagus short, curved, basally swollen. Juxta a small plate passing into the anellus, which stands out above the aedeagus as a bifid plate, the apices of which articulate with the transtilla. Harpes long, narrow, slightly tapering to rounded apex; sacculus undefined; transtilla formed by the produced basal angle of the harpe, not a separate process as in the rest of the family. Vinculum moderate, broader than in other genera.

KEY TO THE SPECIES OF *PROSELENA*.

Socii very small; juxta angular; anellus not bifid above; vinculum broad at apex	*niphostrota*.
Socii moderate; juxta rounded; anellus bifid above; arms of vinculum not broad at apex	*antiquana*.

LETTERING.

(Lettering: a, anus; ae, aedeagus; an, anellus; b, barb on aedeagus; c, cornuti; de, ductus ejaculatorius; g, gnathos; h, harpe; ht, hair-tuft beyond eighth segment; j, juxta; s, socii; sa, sacculus; t, tegumen; tr, transtilla; u, uncus; ua, upper extension of anellus; v, vinculum; ve, vesica. Unless otherwise stated the views of the genitalia (A) and the aedeagus (D) are from the lateral aspect, that of the harpe (B) is from within, and that of the uncus a dorsal one.)

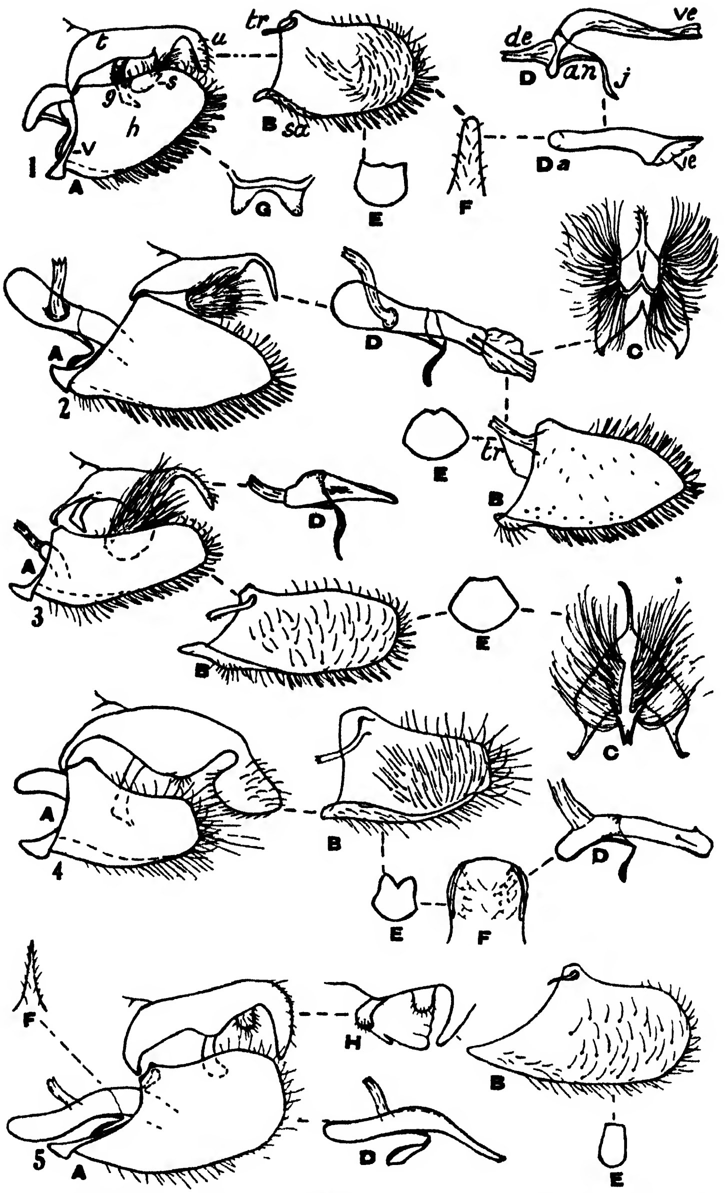


FIG. 1.—*Cnephasia microbathra* Meyr. A, male genitalia B, harpe. D, aedeagus. Da, aedeagus, ventral view. E, juxta. F. uncus. G, transtilla.

FIG. 2.—*C. jactatana* Walk. A, male genitalia. B, harpe. C, tegumen, ventral view. D, aedeagus. E, juxta.

FIG. 3.—*C. incessana* Walk. A, male genitalia B, harpe. C, tegumen, ventral view. D, aedeagus. E, juxta.

FIG. 4.—*C. latomana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F. uncus.

FIG. 5.—*C. imbriferana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. H. socii, gnathos and anal tube, lateral view.

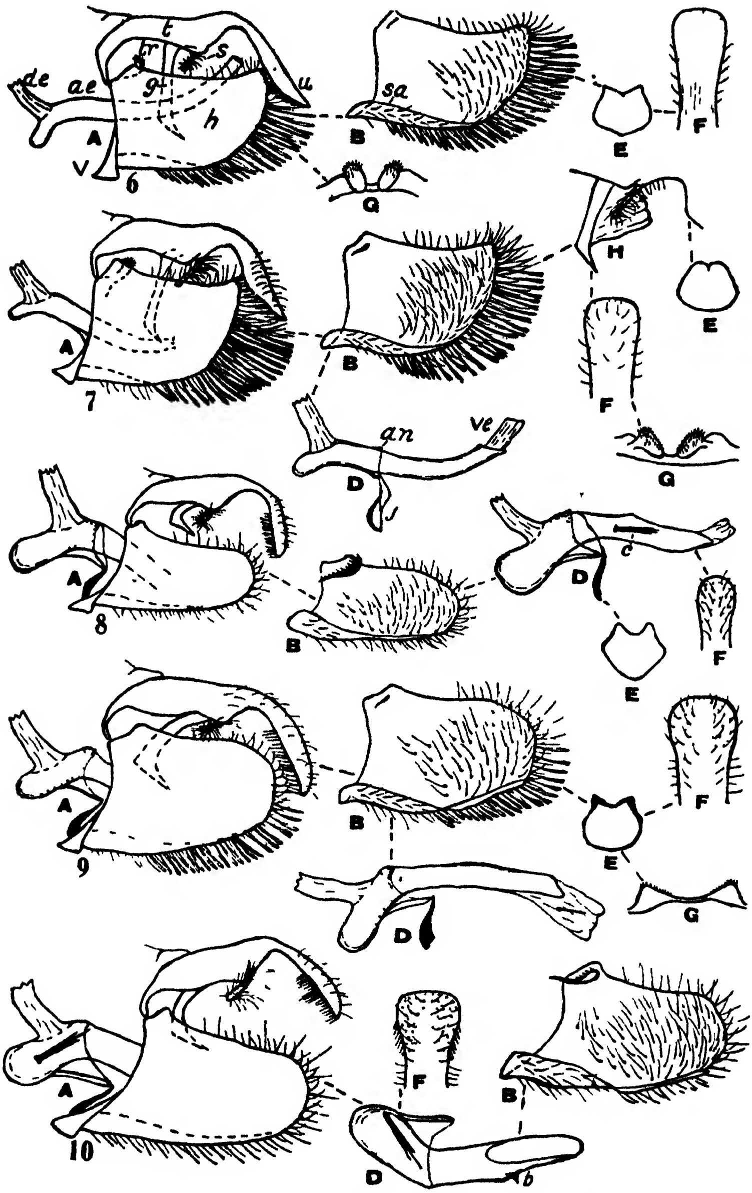


FIG. 6.—*C. sphenias* Meyr. A, male genitalia. B, harpe. E, juxta. F. uncus. G, transtilla.

FIG. 7.—*C. fastigata* Philp. A, male genitalia. B, harpe. D, aedeagus. E. juxta. F, uncus. G, transtilla. H, socii, gnathos and anal tube, lateral view.

FIG. 8.—*Harmologa sanguinea* Philp. A, male genitalia. B, harpe. D, aedeagus. E. juxta. F, uncus.

FIG. 9.—*H. festiva* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. G, transtilla.

FIG. 10.—*H. reticularis* Philp. A, male genitalia. B, harpe. D, aedeagus. F, uncus.

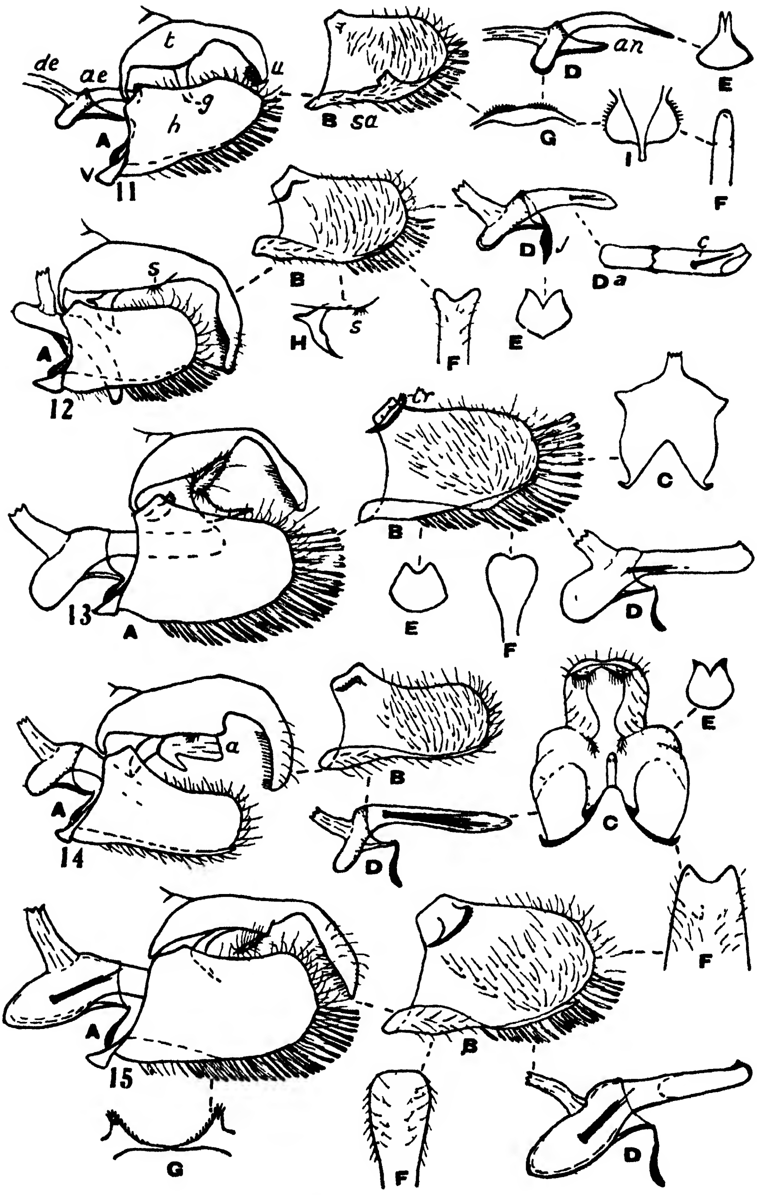


FIG. 11.—*H tenebiosa* Philp. A, male genitalia B, harpe D aedeagus. E, juxta. F, uncus. G, transtilla I, gnathos, caudal view.
FIG 12.—*H oblongana* Walk. A, male genitalia. B, harpe. D, aedeagus. Da, aedeagus, ventral view. E, juxta. F, uncus. H, socii and gnathos, lateral view.
FIG. 13.—*H. petiias* Meyi. A, male genitalia. B, harpe. C, tegumen, dorsal view. D, aedeagus. E, juxta. F. uncus.
FIG. 14.—*H. amplexana* Z. A, male genitalia. B, harpe. C, tegumen, ventral view. D, aedeagus. E, juxta. F, uncus.
FIG. 15.—*H. columella* Meyr. A, male genitalia. B, harpe. D, aedeagus. F, uncus. G, transtilla.

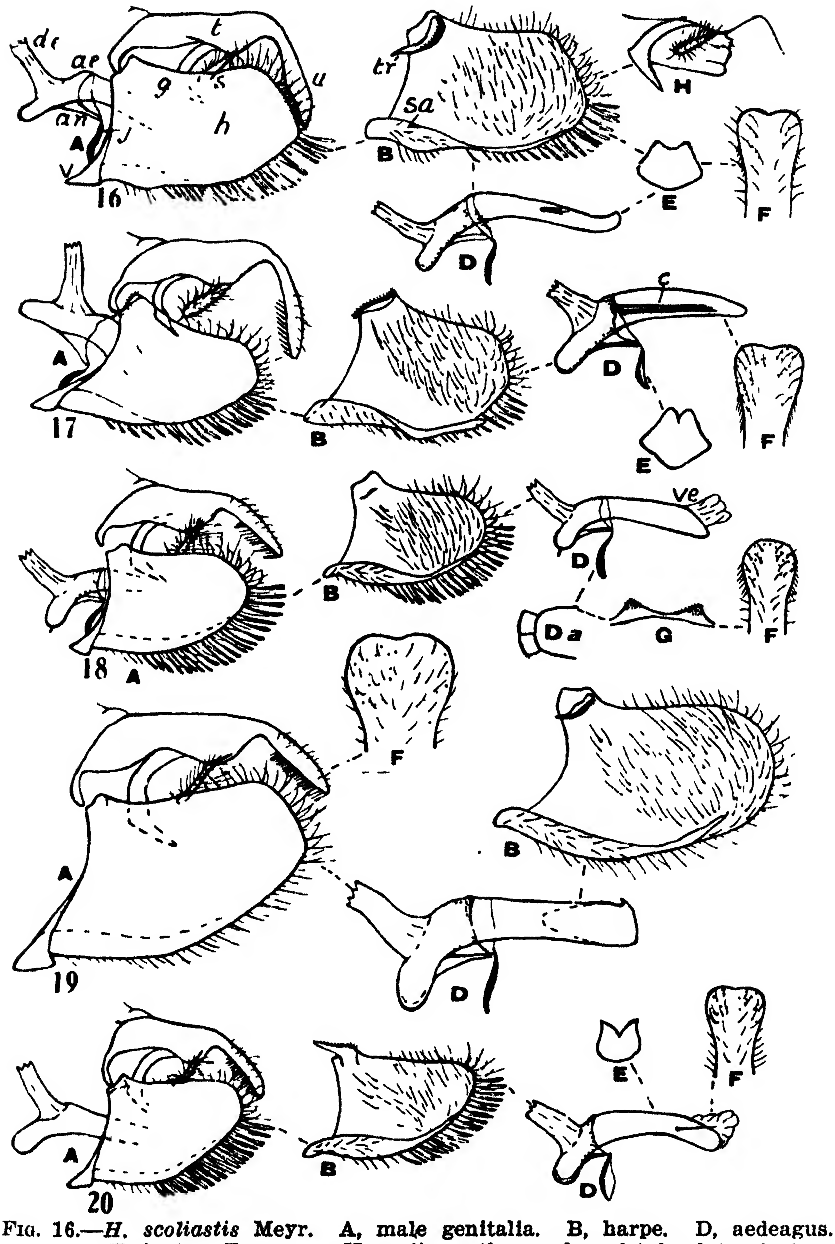


FIG. 16.—*H. scoliastis* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. H, socii, gnathos and anal tube, lateral view.

FIG. 17.—*H. pontifica* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 18.—*Gelophaula tributaria* Philp. A, male genitalia. B, harpe. D, aedeagus. Da, aedeagus, basal portion, ventral view. G, transtilla.

FIG. 19.—*G. trisulca* Meyr. A, male genitalia. B, harpe. D, aedeagus. F, uncus.

FIG. 20.—*G. palliata* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

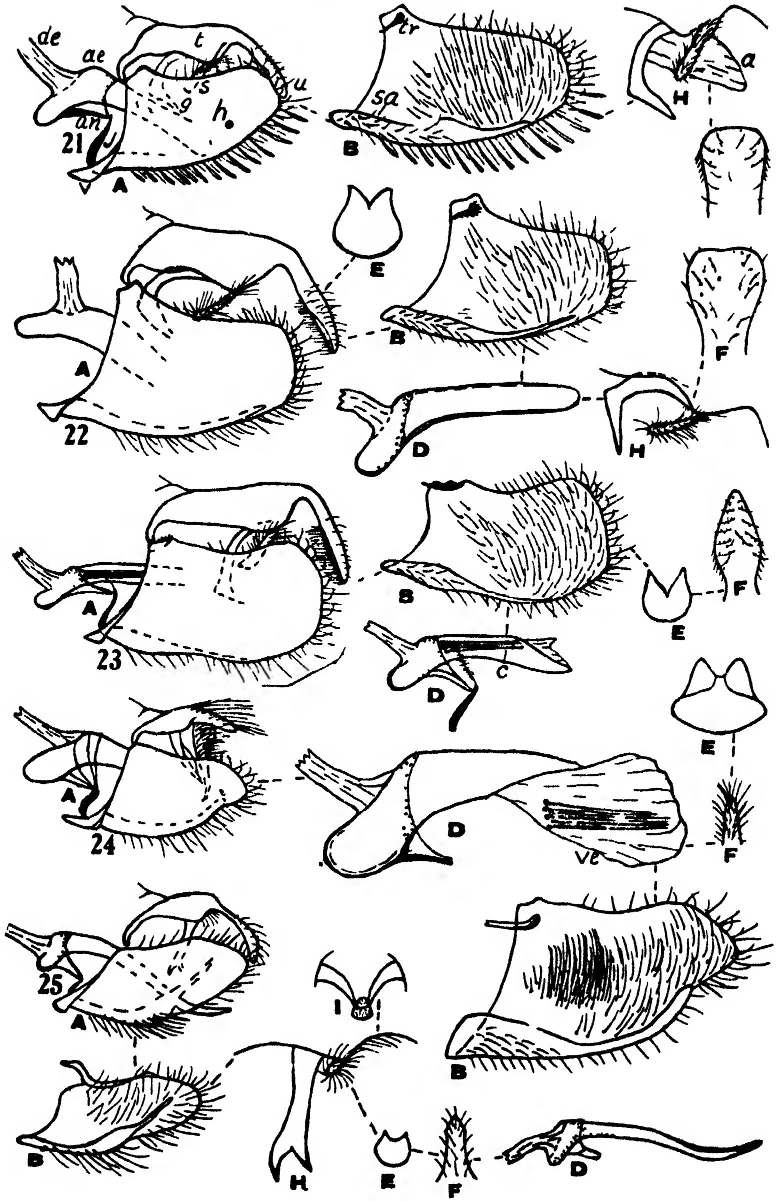


FIG. 21.—*G. siraea* Meyr. A, male genitalia. B, harpe. F, uncus. H, socii. gnathos and anal tube, lateral view.
FIG. 22.—*G.* n. sp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. H, socii and gnathos, lateral view.
FIG. 23.—*Ctenopseustis obliquana* Walk. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
FIG. 24.—*Epalxiphora axenana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
FIG. 25.—*Ecclitica hemiclista* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. H, socii and gnathos. I, gnathos, dorso-caudal view.

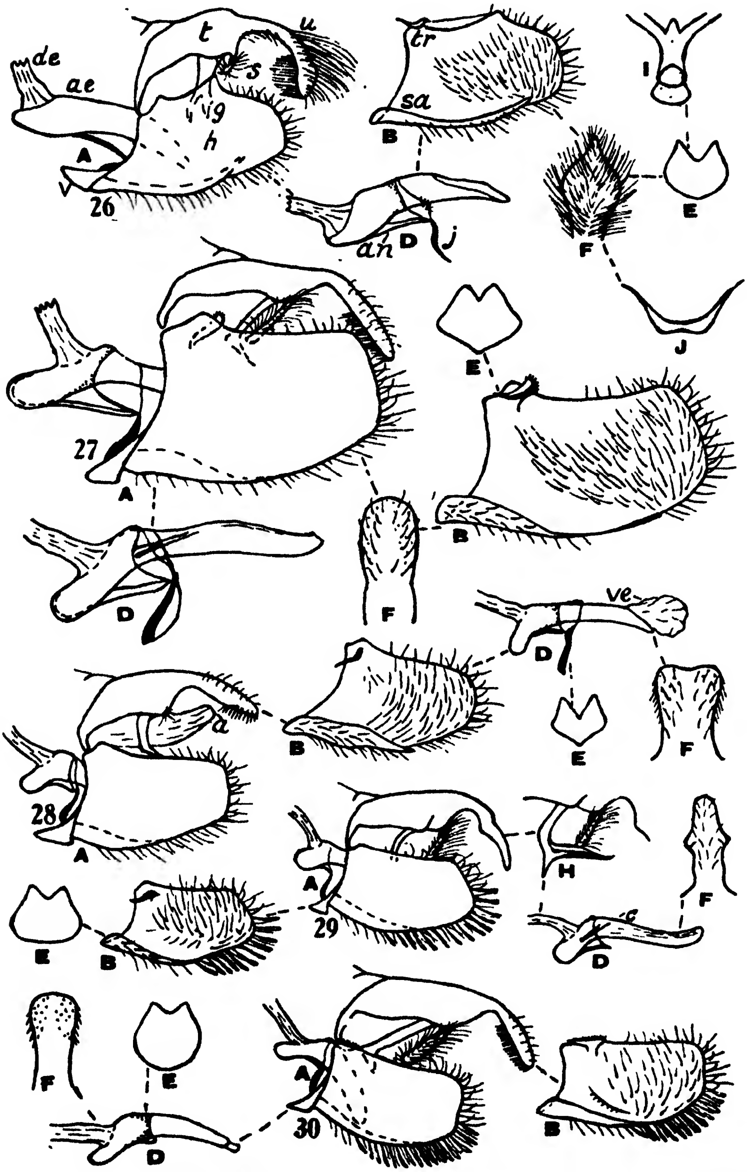


FIG. 26.—*E. torogramma* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. I, gnathos, dorso-caudal view. J. vinculum.
FIG 27.—*Philocryptica polypodii* Watt. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
FIG. 28.—*Ascerodes prochlora* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
FIG. 29.—*Epichorista abdita* Philp. A, male genitalia. B, harpe. D, aedeagus. F, uncus. H, socii and gnathos, lateral view.
FIG. 30.—*E. emphanes* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

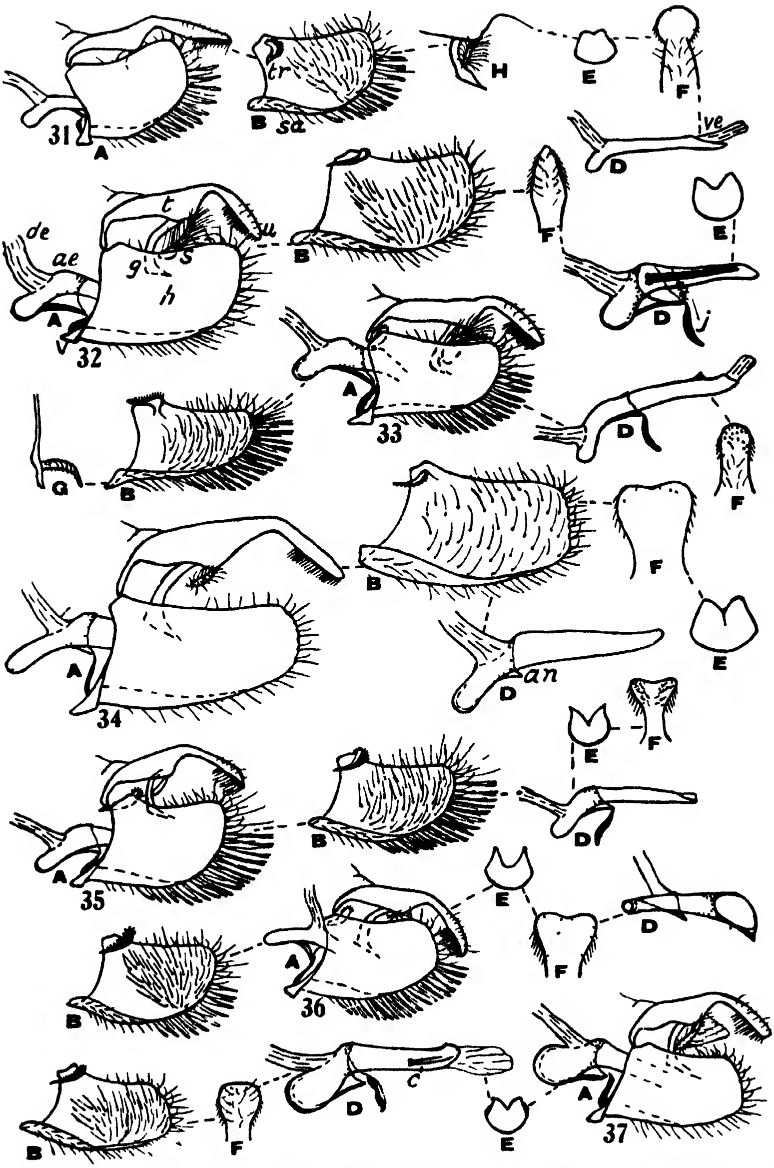


FIG. 31.—*E. speciosa* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. H, socii and gnathos, lateral view.
FIG. 32 —*E. persecta* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
FIG. 33.—*E. allogama* Meyr. A, male genitalia. B, harpe. D, aedeagus. F, uncus. G, transtilla, dorsal view.
FIG. 34.—*E. fraudulenta* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
FIG. 35.—*E. aspistana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
FIG. 36.—*E. hemionana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
FIG. 37.—*E. siriana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

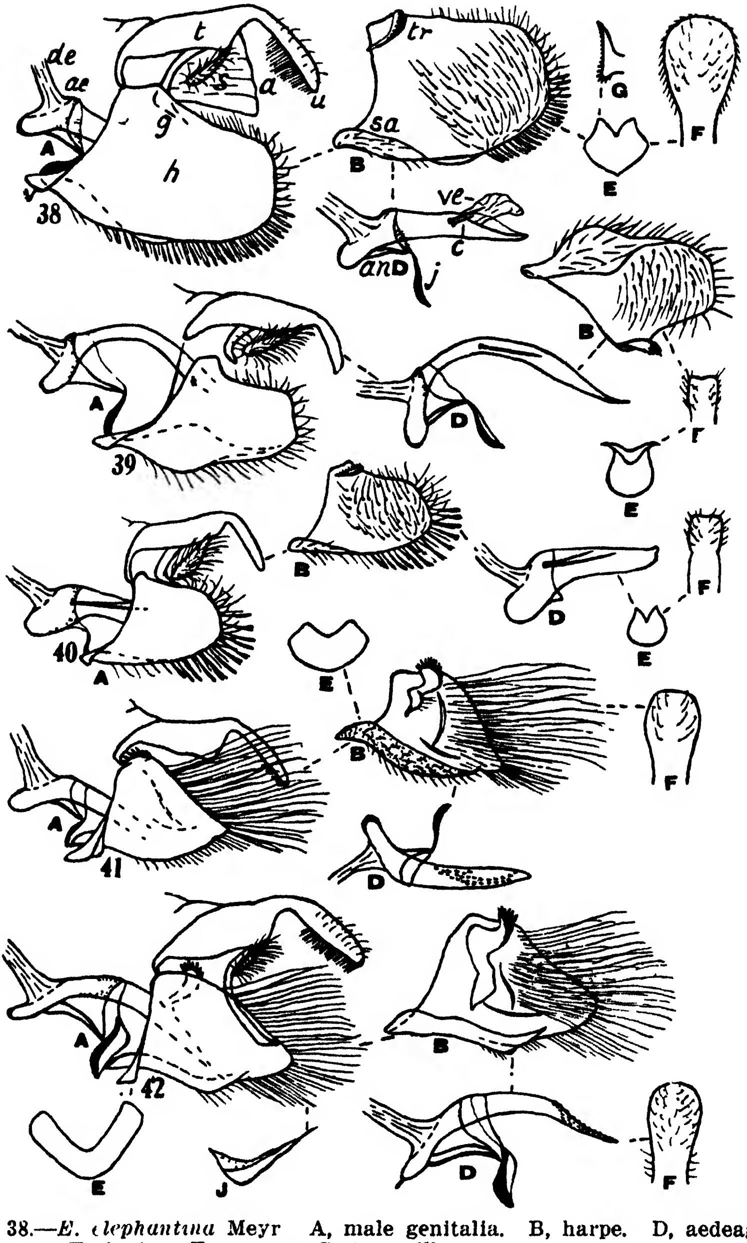


FIG. 38.—*E. elephantina* Meyr A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. G, transtilla.

FIG. 39.—*E. eribola* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 40.—*E. zatrophana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 41.—*Eurythecta paraloxa* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 42.—*E. zelaea* Meyr. A, male genitalia. B, harpe. D, aedeagus. E. juxta. F, uncus. J, arm of vinculum.

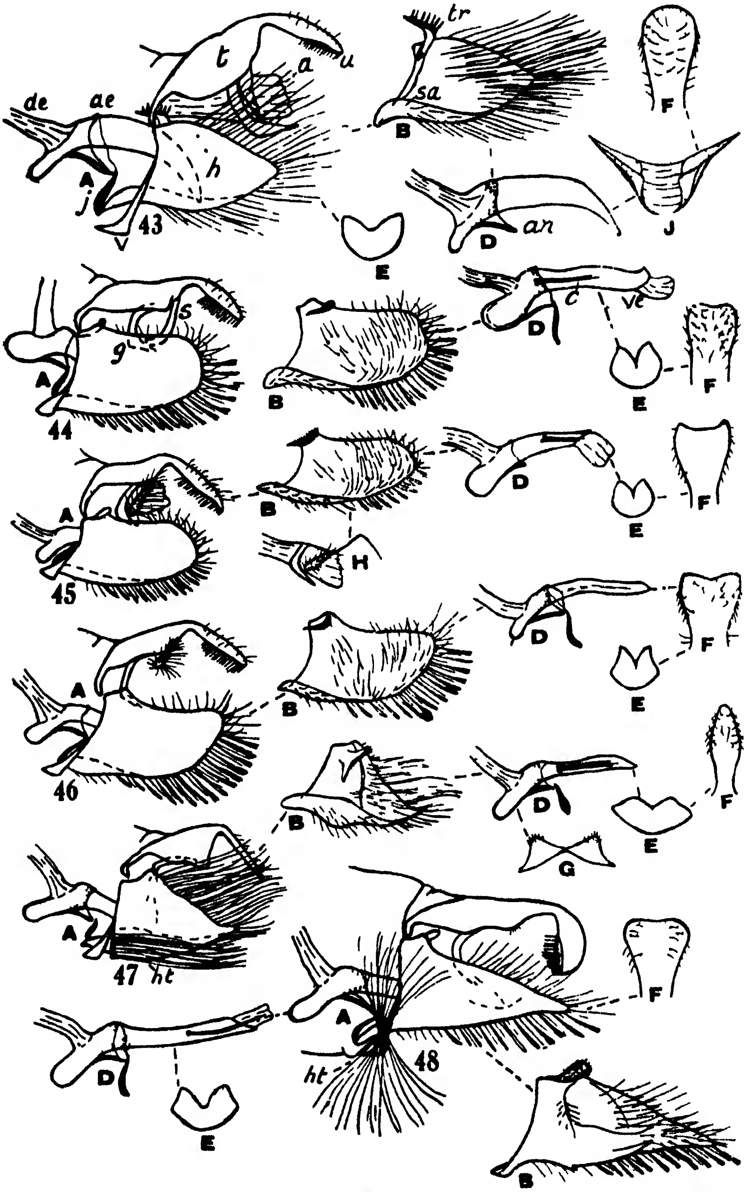


Fig. 43.—*E. robusta* Butl. A, male genitalia B, harpe. D, aedeagus. E, juxta. F, uncus. J, vinculum.
Fig. 44.—*E. eremana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
Fig. 45.—*E. loxias* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. H. socii, gnathos and anal tube, lateral view.
Fig. 46.—*E. curva* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
Fig. 47.—*Tortrix leucaniana* Walk A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. G, transtilla.
Fig. 48.—*T. argentosa* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

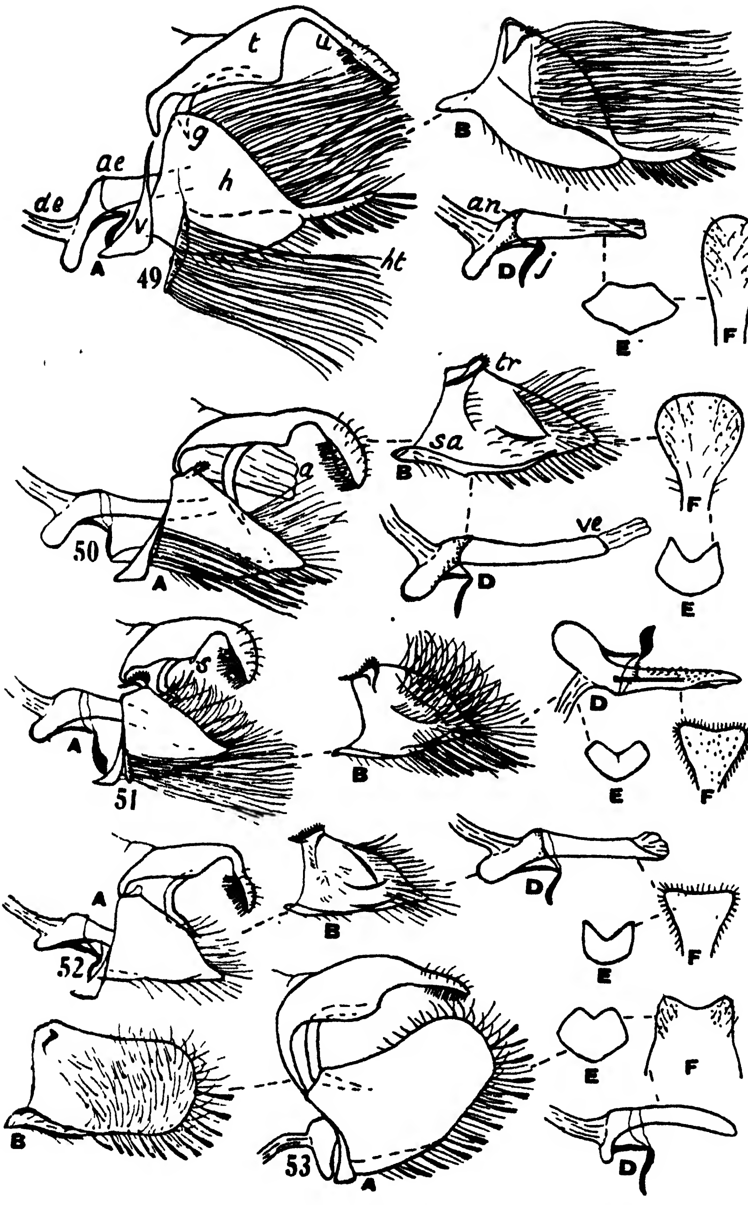


FIG. 49.—*T. postvittana* Walk. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 50.—*T. subdola* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 51.—*T. indigestana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 52.—*T. maculosa* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 53.—*T. molybditis* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

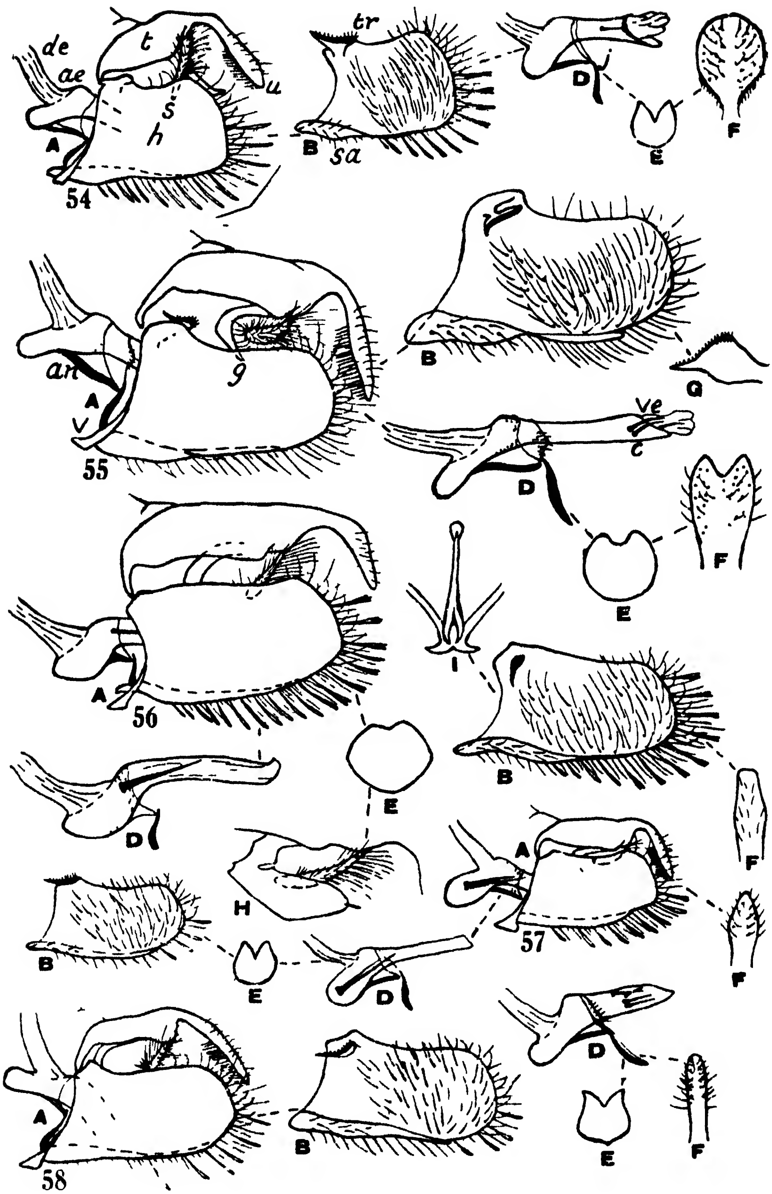


FIG. 54.—*T. excessana* Walk. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 55.—*T. tigris* Philp. A, male genitalia. B, harpe. D, eadeagus. E, juxta. F, uncus. G, transtilla.

FIG. 56.—*T. xestodes* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. H, socii and gnathos, lateral view. I, gnathos, ventral view.

FIG. 57.—*T. orthropis* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 58.—*T. pictoriana* Feld. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F uncus.

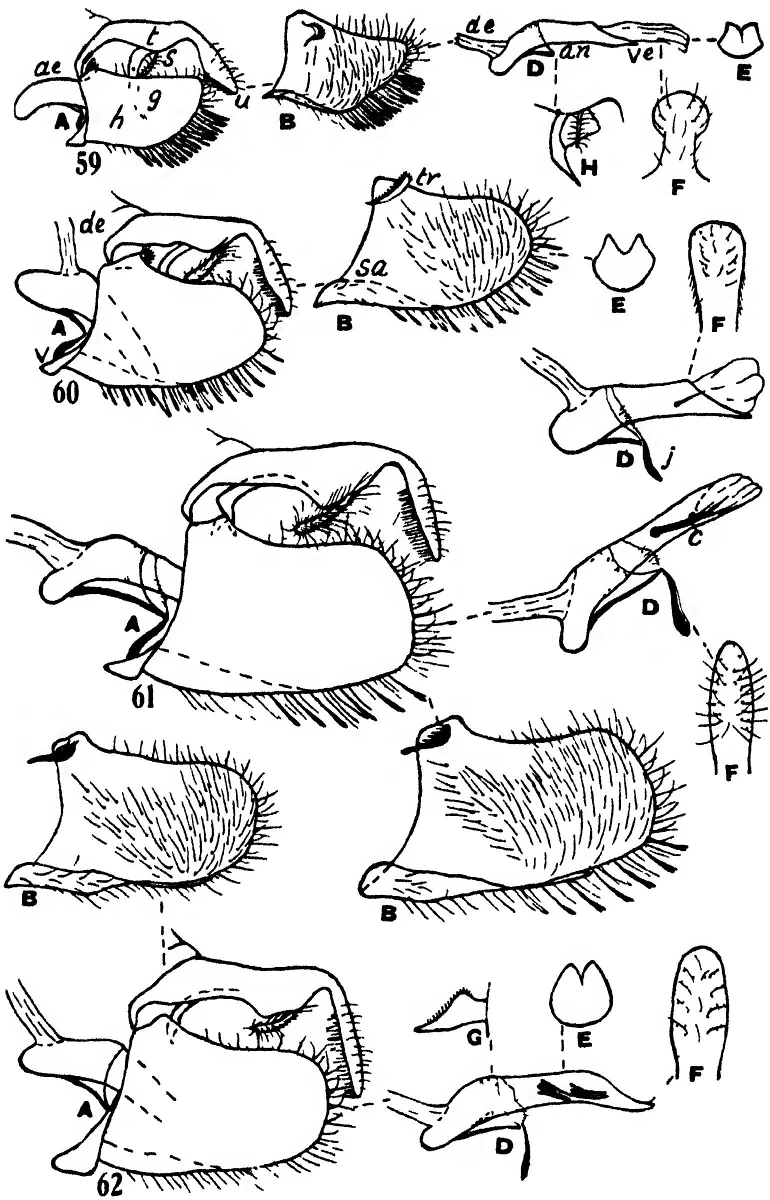


FIG. 59.—*T. incendiaria* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. H, socii, gnathos and anal tube, lateral view.
FIG. 60.—*T. characana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.
FIG. 61.—*T. spatiosa* Philp. A, male genitalia. B, harpe. D, aedeagus. F, uncus.
FIG. 62.—*T. conditana* Walk. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F. uncus. G, transtilla.

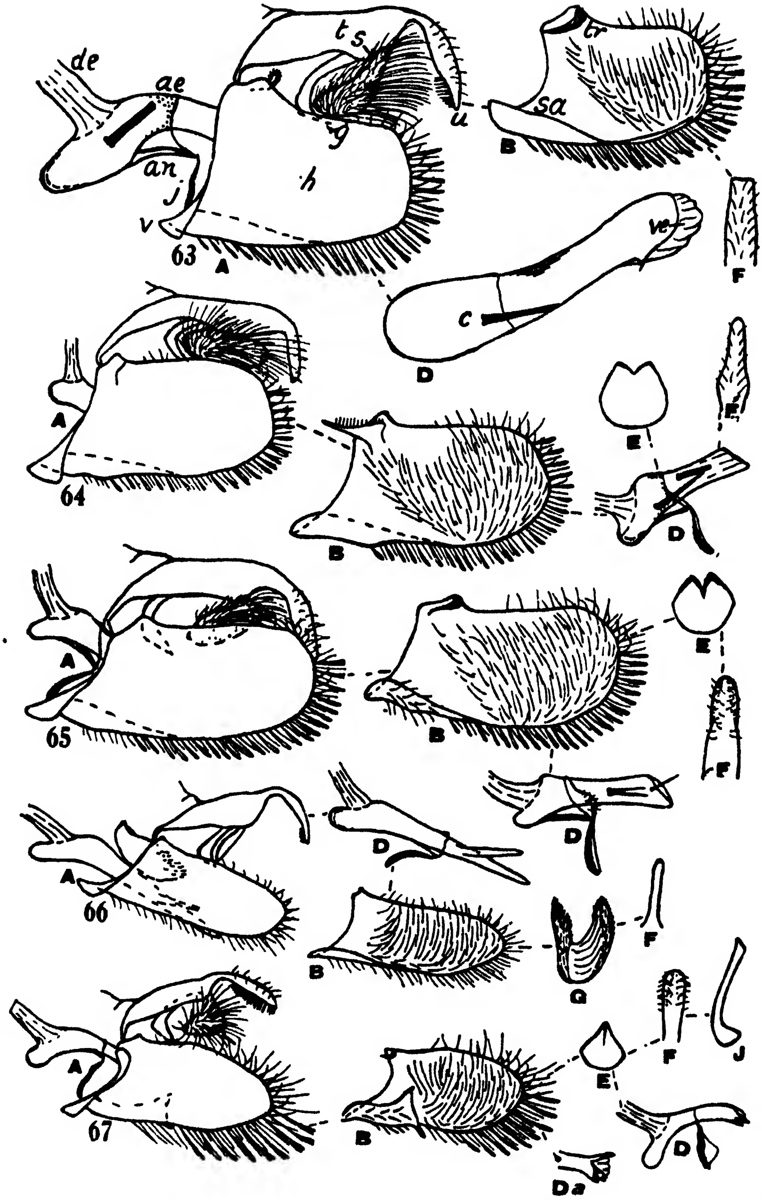


FIG. 63.—*T. crypsidora* Meyr. A, male genitalia. B, harpe. D, aedeagus. F, uncus.

FIG. 64.—*T. flavescens* Butl. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 65.—*T. fervida* Meyr. A, male genitalia. B, harpe. D, aedaegus. E, juxta. F, uncus.

FIG. 66.—*Capua cyclobathra* Meyr. A, male genitalia. B, harpe. D, aedeagus. F, uncus. G, transtilla, obliquely ventral view.

FIG. 67.—*C. intractana* Walk. A, male genitalia. B, harpe. D, aedeagus. Da, apex of aedeagus, ventral view. E, juxta. F, uncus. J, arm of vinculum.

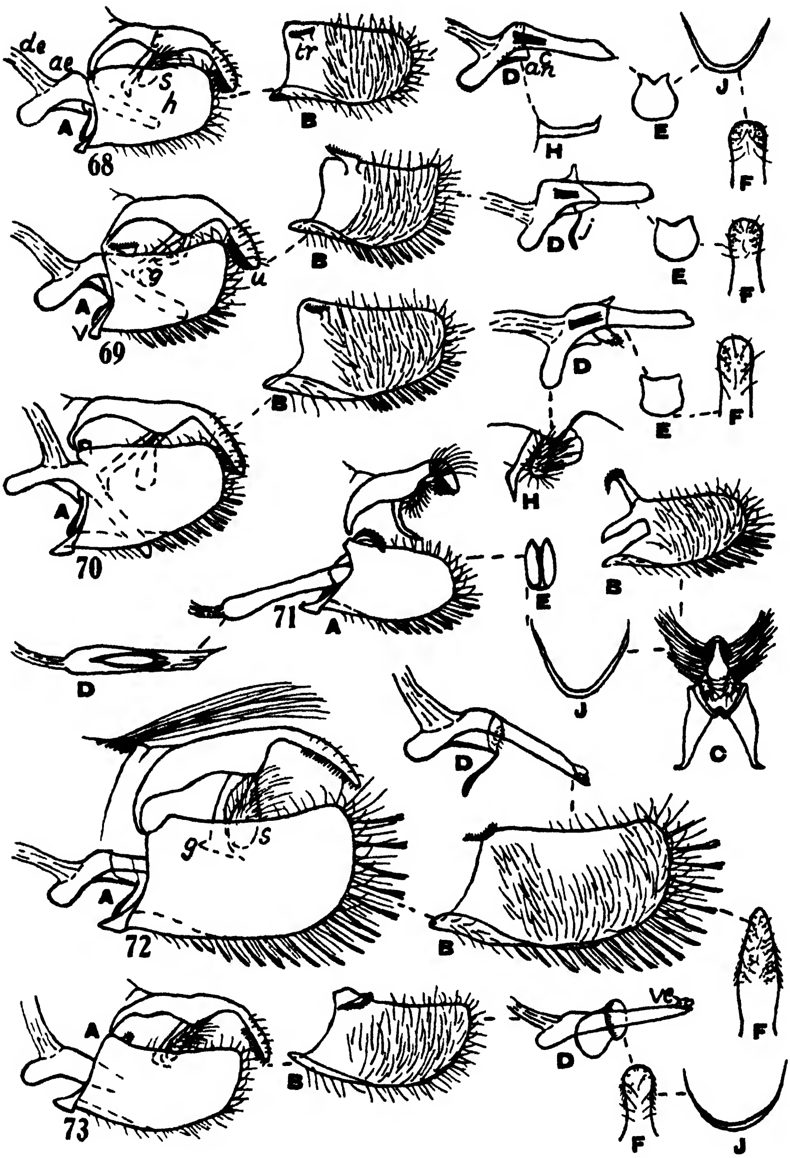


FIG. 68.—*C. arouata* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. I, gnathos, lateral view. J, vinculum

FIG. 69.—*C. plinthoglypta* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 70.—*C. plagiatana* Walk. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus. H, socii, gnathos and anal tube, lateral view.

FIG. 71.—*C. semiferana* Walk. A, male genitalia. B, harpe. C, tegumen, lateral view. D, aedeagus, dorsal view. E, juxta. J, vinculum.

FIG. 72.—*Catamacta lotinana* Meyr. A, male genitalia. B, harpe. D, aedeagus. F, uncus.

FIG. 73.—*C. rureana* Feld. A, male genitalia. B, harpe, D, aedeagus, obliquely lateral view. F, uncus J, vinculum.

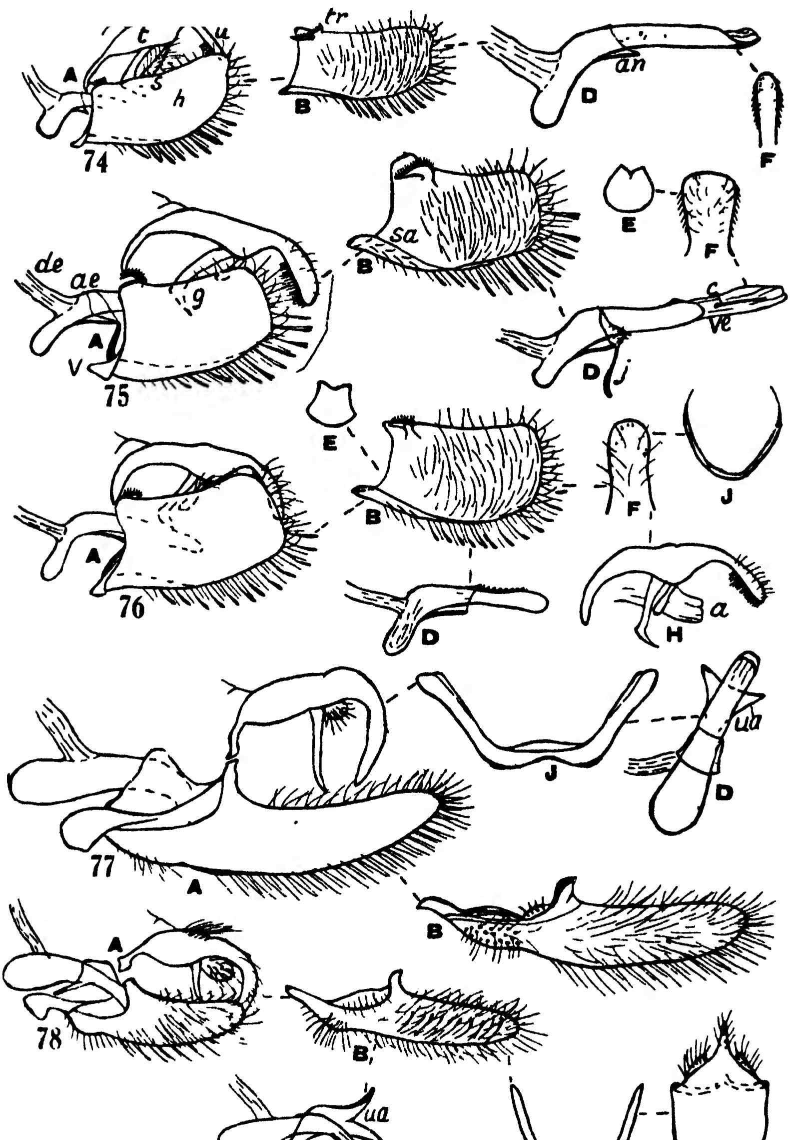


FIG. 74.—*C. gavisana* Walk. A, male genitalia. B, harpe. D, aedeagus. F, uncus.

FIG. 75.—*Pyrgotis consentiens* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta. F, uncus.

FIG. 76.—*P. pyramidias* Meyr. A, male genitalia. B, harpe. C, tegumen, lateral view. D, aedeagus. E, juxta. F, uncus. J, vinculum.

FIG. 77.—*Proselena niphostrota* Meyr. A, male genitalia. B, harpe. D, aedeagus, ventral view. J, vinculum.

FIG. 78.—*P. antiquana* Walk. A, male genitalia. B, harpe. C, tegumen, dorsal view. D, aedeagus, obliquely lateral view. J, vinculum.

The Male Genitalia of the New Zealand Eucosmidae.

By ALFRED PHILPOTT, Hon. Research Student in Lepidoptera, Cawthron Institute, Nelson.

[*Read before the Nelson Philosophical Society, 1st August, 1928; received by Editor, 5th August, 1928, issued separately, 16th November, 1928.*]

THE Eucosmidae of New Zealand comprise only 20 known species, belonging to 7 genera, a mere fragment of what is elsewhere a very extensive group. In the northern hemisphere the family is particularly well represented, Heinrich's recent revisions of the North American species dealing with over 600 forms, distributed through more than 60 genera. In view of the paucity of the New Zealand representation, it is inadvisable to offer any generalizations of a speculative or critical character and the following article will therefore only aim at being of use as an aid to specific determination.* It may, however, be briefly stated that in the Eucosmidae the harpes are usually well developed and more or less constricted at the middle, the aedeagus short and curved or pistol-shaped, the socii present or absent, the gnathos usually weak or absent, the uncus absent or, if present, small and frequently bifid, the tegumen rather narrow and the vinculum a weak band, without saccus. It should be noted that the ventral surface of the anal tube is frequently more or less chitinized, particularly laterally, and that the gnathos often merges with this chitinization, thus giving the former the appearance of a much more developed organ than it really is. In none of the species examined could I find an instance of the gnathos forming a separate chitinized band beneath or across the anal tube.

Hendicasticha Meyrick.

Monotypic and endemic. No material has been available for the study of this genus, the single species being apparently rare and local.

Spilonota Stephens. (Figs. 1 to 5.)

One of the smaller genera. Fairly well represented in Australia, where three of the New Zealand species occur also. Of the eight New Zealand species three have not been available for dissection.

†The eighth segment is considerably modified, the caudal margin being deeply excavated laterally and ventrally. Tegumen narrow

*For a general consideration of the family (sens. lat.) the reader is referred to Heinrich's recent works: "Revision of the North American Moths of the subfamily Eucosminae.' *U.S. National Museum Bulletin*, 123 (1923), and "Revision of the North American Moths of the subfamilies Laspeyresiinae and Olethreutinae." *U.S. National Museum Bulletin*, 132 (1926).

†It must be understood that the generic diagnoses are applicable only to such species as are dealt with in the present paper.

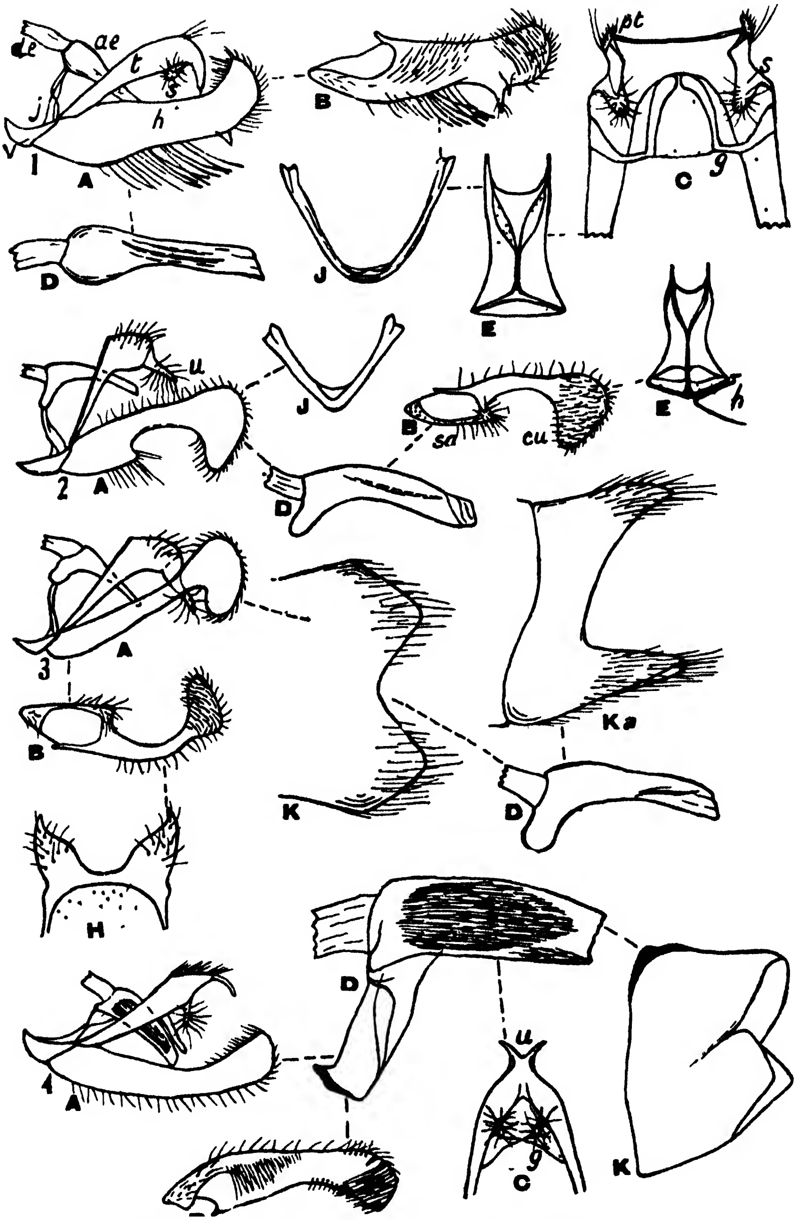


FIG. 1.—*Spilonota ejectana* Walk. A, male genitalia. B, harpe C, tegumen, ventral view. D, aedeagus. E, juxta and anellus. J, vinculum.

FIG. 2.—*S. zopherana* Meyr. A, male genitalia. B, harpe. D, aedeagus. E, juxta and anellus with base of harpe. J, vinculum.

FIG. 3.—*S. partheniata* Meyr. A, male genitalia. B, harpe. D, aedeagus. H, socii, ventral view. K, eighth segment, ventral view. Ka, eighth segment, lateral view.

FIG. 4.—*S. macropetana* Meyr. A, male genitalia. B, harpe. C, tegumen, ventral view. D, aedeagus. K, eighth segment, lateral view.

laterally, broader dorsally, not fused with vinculum; uncus absent or but slightly developed. Socii present, porrect or drooping, usually covered outwardly with long backwardly directed hair. Gnathos weak or absent. Aedeagus short, curved, more or less swollen basally; cornuti usually present. Anellus opening out ventrally and fusing with diamond-shaped juxta; this ventral development of the anellus supports the aedeagus as on a hinge and has the effect of pushing the organ much higher between the arms of the tegumen than is usual. Vinculum narrow and weak, without saccus. Harpes long, more or less constricted at middle, inner surface of cucullus usually densely haired and frequently spine-bearing.

KEY TO THE SPECIES OF *SPILONOTA*.

1. Uncus absent	2.
Uncus present	4.
2. Gnathos present; apex of tegumen broadly truncate with a pair of lateral processes directed triangularly downwards; harpes moderately broad, little constricted, with a pair of prong-like processes from within near ventral margin at $\frac{2}{3}$	*ejectana* Walk.
Gnathos absent	3.
3. Sacculus prominent on lateral view; caudal margin of cucullus armed with series of very short but stout spines	*zopherana* Meyr.
Sacculus hardly noticeable on lateral view; series of spines round caudal margin of cucullus smaller than in *zopherana*	*partheniata* Meyr.
4. Uncus bifid; socii weak, finger-like; harpes narrow; aedeagus short, almost filled with bundle of cornuti	*macropetana* Meyr.
Uncus entire; socii well chitinized rounded vertical plates bent over horizontally above; harpes broad; aedeagus rather long, a moderate bundle of cornuti in apical $\frac{1}{2}$; anellus widely expanded ventrally	*chaophila* Meyr.

Eucosma Hubner. (Fig. 6.)

Meyrick has described 4 New Zealand species of this very extensive genus, but only one of these seems to be known to New Zealand collectors.

Eucosma querula Meyr.

The male genitalia of this species are not only entirely different from the ordinary type of the genus, but do not approach those of any species of the family of which figures have been available for comparison. It is a question whether a form with such widely different sex-organs should not be separated generically.

LETTERING.

Lettering: a, anus; aa, aperture for aedeagus; ae, aedeagus; an, anellus; at, anal tube; cu, cucullus; de, ductus ejaculatorius; ea, upper extension of anellus; g, gnathos; h, harpe; j, juxta; pt, apical processes of tegumen; s, socii; sa, saccus; t, tegumen; u, uncus; v, vinculum; vs, vestigial socii; vt, ventral plate of anal tube. Unless otherwise stated the views of the genitalia (A) and aedeagus (D) are from a lateral aspect; those of the harpe (B) are from within.

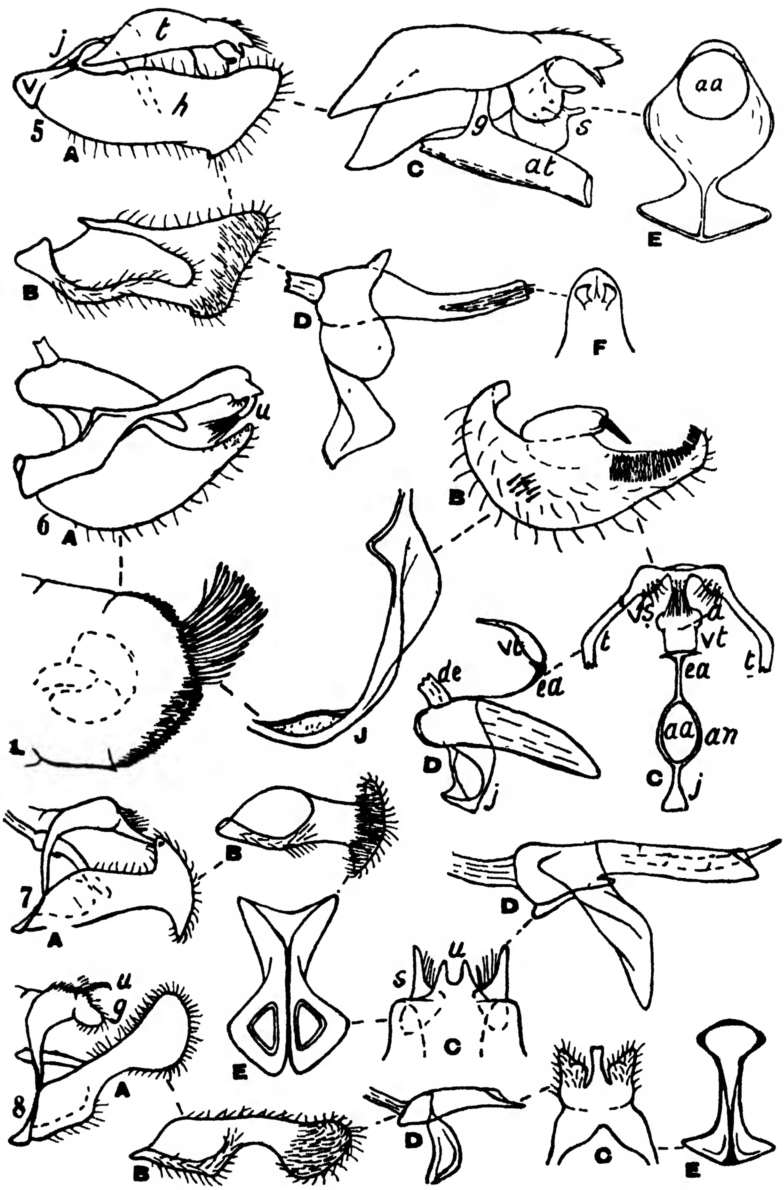


FIG. 5.—*S. chaophila* Meyr. A, male genitalia. B, harpe. C, tegumen, obliquely lateral view. D, aedeagus. E. juxta and anellus.

FIG. 6.—*Eucosma querula* Meyr. A, male genitalia. B, harpe. C, tegumen with connections from juxta to uncus, semi-diagrammatic, caudal view. D, aedeagus. J, vinculum. L, end of abdomen with genitalia not exerted.

FIG. 7.—*Raumatia trimaculata* Philp. A, male genitalia. B, harpe. C, apical portion of tegumen, dorsal view. D, aedeagus. E, juxta and anellus.

FIG. 8.—*R. potamias* Meyr. A, male genitalia. B, harpe. C, tegumen, dorsal view. D, aedeagus. E, juxta and anellus.

The genitalia are normally concealed within the eighth segment, which is in turn partly withdrawn within the seventh. A dense tuft of long curved hair-scales rises from the conjunctiva beyond the eighth segment and protrudes through the opening, taking the place of the usual anal tuft. The genitalia proper form a compact, more or less rounded mass. The tegumen is narrow and fused with the much broader vinculum, the organ being sharply angled at the point of junction. The uncus is small, bent sharply downwards and bears a terminal brush of moderately long hair. On each side of the uncus the tegumen is slightly dilated, the area carrying a few weak hairs; probably this represents the vestigial socii. The gnathos is absent. The aedeagus is stout and tusk-like. The anellus is of the Eucosmid type ventrally, merging with the rather short angular juxta, but dorsally it throws out a thin well chitinized spring-like strip which connects with the ventral chitinized plate of the anal tube. The harpes are broad and strongly rounded on the basal $\frac{2}{3}$, the apical third being much narrowed and densely clothed with short blunt spines along the upper margin; attached to the upper margin is a rounded flap, armed apically with a stout blunt socketed spur. This flap is normally folded back on the harpe, but is hinged and freely moveable.

Raumatia n. g. (Figs. 7 to 9.)

A genus, characterized elsewhere in this volume, erected for the reception of three species formerly placed in *Eurythecta* (Tortricidae). I am indebted to Dr. A. Busck, of the U.S. National Museum, for drawing my attention to the misplacement of these forms; an examination of the genitalia at once confirmed his views.

Tegumen small; uncus a pair of very weak well separated processes or a minute median one. Socii broad irregular plates or more rod-like organs. Gnathos absent as a chitinized organ and apparently absorbed in the socii. Aedeagus rather small, slightly swollen basally, very little curved. Anellus and juxta normal. Harpes large, constricted above sacculus; a few hairs on sacculus and apical part of cucullus, but median area naked. Vinculum very small and weak.

KEY TO THE SPECIES OF *RAUMATIA*.

1. Socii narrow apically; uncus a pair of weak prongs; harpes with upper and lower angles produced	*trimaculata* Philp.
Socii broad apically; uncus a single weak prong; harpes deeply emarginate on lower margin, apical angle not produced	2.
2. Harpes with upper margins sinuate, "neck" narrow; juxta broader than long	*potamias* Meyr.
Harpes with upper margin not sinuate; "neck" broader; juxta diamond-shaped	*varia* Philp.

Crocidosema Zeller. (Fig. 10.)

Within the last few years a representative of this genus has established itself in New Zealand. This is *C. plebeiana* Z. an insect widely spread throughout the drier parts of the world.

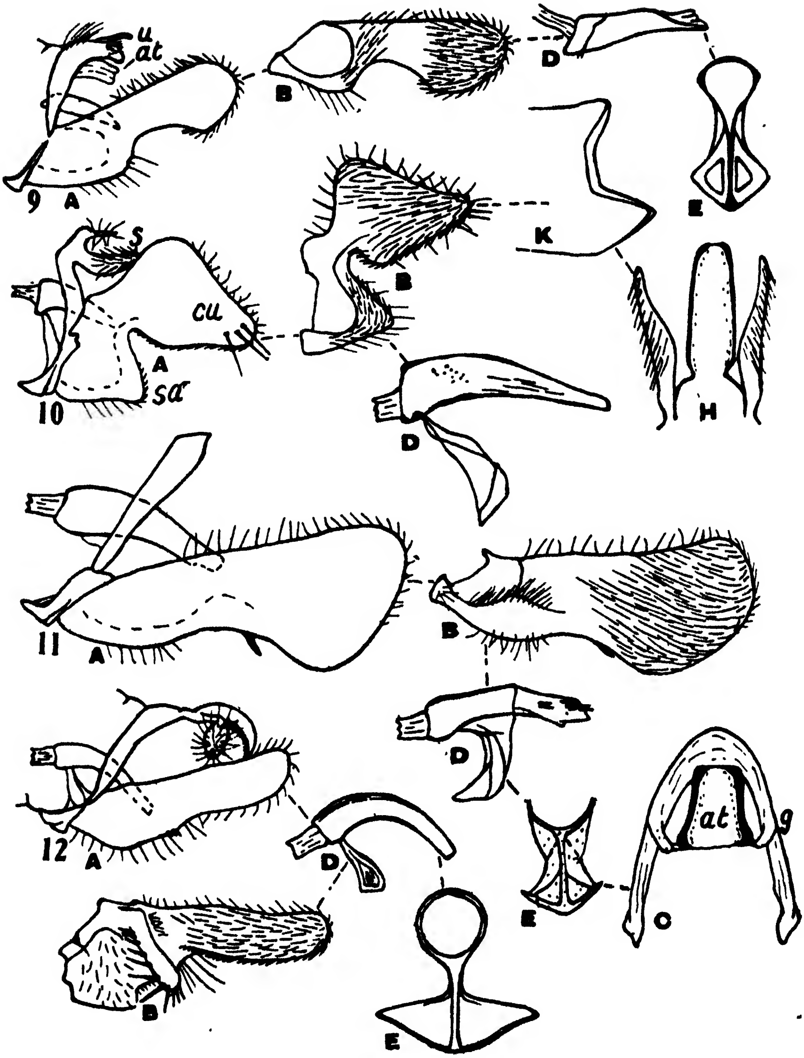


FIG. 9.—*R. varia* Philp. A, male genitalia. B, harpe. D, aedeagus. E, juxta and anellus.
FIG. 10.—*Crocidosema plebeiana* Z. A, male genitalia. B, harpe. D, aedeagus. H, socii, gnathos and anal tube, ventral view. K, eighth segment, lateral view.
FIG. 11.—*Laspeyresia pomonella* L. A, male genitalia. B, harpe. C, tegumen, ventral view. D, aedeagus. E, juxta and anellus.
FIG. 12.—*Bactra* sp. A, male genitalia. B, harpe. D, aedeagus. E, juxta and anellus.

C. plebeiana Z.

The eighth segment is modified in much the same way as in *Spilonota*, being deeply emarginate laterally and dorsally. Tegumen narrow, fused with vinculum. Uncus a very weak finger-like process. Socii rather broad, pointed, porrect. Gnathos a pair of weak thin strips which merge in the lateral chitinization of the anal tube. Aedeagus short, swollen basally and tapering to apex, without cornuti. Juxta similar to *Spilonota*; anellus less developed. Harpes deeply and widely cleft on ventral margin, resulting in a broad triangular cucullus and a similar but smaller sacculus; three long stout spines on outer surface of cucullus near apex. Vinculum as broad as tegumen, saccus not developed.

Laspeyresia Hubner. (Fig. 11.)

The world-wide orchard pest, *L. pomonella* L., is the only New Zealand member of this widely spread genus.

L. pomonella L.

Tegumen narrow, not fused with vinculum; uncus absent. Socii absent. Gnathos weak, connecting with lateral chitinized strips of anal tube, but with a noticeable weakening at point of junction. Aedeagus moderately long, slightly swollen basally, 7 or 8 short stout cornuti, a slight obliquely longitudinal ridge towards apex beneath. Anellus and juxta normal. Vinculum moderately broad with slight saccus Harpes large, broad, constriction at neck moderate, a short stout prong projecting from ventral margin below cucullus, cucullus dilated, rounded.

Bactra Stephens. (Fig. 12.)

Of this large and widely distributed genus four species have been recorded from New Zealand. These species are extremely alike and in the absence of certainty as to determination I can do nothing further than describe the genitalia of one form (probably *B. xystrota* Meyr.), leaving the specific identification open for the present. A much larger form, of which I possess some examples, does not show any difference in genitalia characters, except perhaps a very small extra rounding of the socii.

Bactra sp.

Tegumen narrow, not fused with vinculum; uncus moderately long, thin, strongly curved, with rows of short strong spines beneath. Socii leaf-like, moderately large, flat. Gnathos absent. Aedeagus moderately long, rather thin, curved, without cornuti. Juxta broad, closer to anellus than in above genera, thus bringing the aedeagus nearer to the bases of the harpes. Harpes with cucullus moderately broad, strongly short-spined along ventral margin, sacculus broad, with a transverse fold bearing 11 strong socketed spines, the inner ones being the larger.

The Male Genitalia of the New Zealand Carposinidae.

By Alfred Philpott, Hon. Research Student in Lepidoptera, Cawthron Institute, Nelson.

[*Read before the Nelson Philosophical Society, 4th July, 1928; received by Editor, 16th July, 1928; issued separately, 16th November, 1928.*]

The Carposinidae form a small family, comprising about a hundred species, chiefly characteristic of Australia and the Hawaiian Islands, but having a few outliers in other regions, as India, Europe, and North America. Though formerly placed under the Tortricoidea, the Carposinidae have latterly been disassociated from that group by several systematists and relegated to a position near the Orneodidae and the Copromorphidae. In the venation the forewing departs from the Tortricid type in the nearness of the origin of Cu 1b to the angle of the cell, in the hindwing by the absence of two branches of M; the tufts of raised scales on the forewing are also quite an unusual character. The labial palpi are certainly more or less Tortricid, but the maxillary palpi seem to be absent or extremely atrophied, whereas in normal Tortricids there are from two to four segments present The antennae again, with their long fine ciliations, depart markedly from the usual Tortricid structure. It is in the male genitalia, however, that the greatest departure from the Tortricoidea is exhibited. Here the two groups have practically nothing in common, the Carposinidae having neither socii nor gnathos and possessing harpes and aedeagus of an altogether different type from the Tortricoidea.

Only one genus of the Carposinidae is represented in New Zealand; this is *Carposina*, of which 15 species have been recorded. Ten of these are dealt with in the present paper, together with a form from Auckland Island previously regarded as a variety of *gonosemana* Meyr. *C. epomiana*, described by Meyrick and afterwards sunk as a synonym of *gonosemana*, proves to be distinct from that species and with Mr. Meyrick's concurrence, is here resuscitated.

Carposina Herrich-Schaffer.

The genitalia are comparatively simple; though there has been considerable specialization the parts are not of elaborate or intricate structure, and there is little difficulty in their interpretation.

The tegumen is well developed and ends in a long thin strongly-curved uncus. Usually the shoulders of the tegumen (the areas on each side of the base of the uncus) are produced into a pair of processes, which may be long and sharp or short and rounded; frequently these bear a patch of stiff spines. Ventrally the margins of the tegumen are usually broadly and irregularly folded inwards, the edges being armed with double series of minute spines or teeth. There is no trace of socii or gnathos. The vinculum is small and weak, the thin arms articulating with the bases of the harpes. The aedeagus consists of a rather long and very thin basal rod, which

opens apically into a concave spoon-like plate the apex of which is cleft into two asymetrical portions. The ductus ejaculatorius connects with this structure at the base of the expanded part and lies along the concave portion. Patches of cornuti, differing greatly in the several species, are frequently, but not invariably, present towards the apex of the aedeagus. In some species the left apical process of the aedeagus is produced into a long ribbon-like filament which protrudes beyond the harpe. As far as I am aware, a similar structure has not been observed in any lepidopterous group; I propose to name it the "vitta." The juxta consists of a pair of short or moderate finger-like processes rising from a small basal plate. The harpes are long and moderately broad. They are divided into a small and simple sacculus and a long cucullus, which often bears one or more processes on its costal margin; a small process (ampulla of Pierce?) is usually present near the base of the sacculus.

KEY TO THE SPECIES OF *CARPOSINA*.

1.	Harpes with processes on costal margin	2.
	Harpes without processes on costal margin	8.
2.	Harpes with apex of cucullus evenly rounded	3.
	Harpes with apex of cucullus produced into a point costally	4.
3.	Lobes of juxta long and narrow	*contactella* Walk.
	Lobes of juxta short and broad	*gonosemana* Meyr.
4.	Aedeagus with long apical filament	5.
	Aedeagus without long apical filament . .	*iophaea* Meyr.
5.	Harpes with apical costal process slight; "ampulla" short, not clavate; juxta with lobes rather incurved apically ..	*charaxias* Meyr.
	Harpes with strong apical process; "ampulla" rather long, clavate; juxta with lobes not incurved apically ..	6.
6.	Harpes with apical process blunt and median process short ..	*cryodana* Meyr.
	Harpes with apical and median costal processes pointed and fairly long .	7.
7.	Harpes with apex rectangularly excised; juxta v-shaped basally	*epomiana* Meyr.
	Harpes with apex roundly excised; juxta u-shaped basally	n. sp.
8.	Harpes with median area of costal margin scobinate	*exochana* Meyr.
	Harpes with median area of costal margin not scobinate	9.
9.	Inner margins of tegumen armed with minute teeth	10.
	Inner margin of tegumen not so armed	*adreptella* Walk.
10.	Harpes with sacculus long, markedly narrowed basally; aedeagus without cornuti; juxta with broad basal plate, lobes slightly dilated	*eriphylla* Meyr.
	Harpes with sacculus moderate, little narrowed basally; aedeagus with lateral patches of cornuti; juxta with narrow basal plate, lobes not dilated . .	*maculosa* Philp.

LETTERING.

(Lettering: ae, aedeagus; ap, ampulla; c, cornuti; cu, cucullus; de, ductus ejaculatorius; h, harpe; pt, apical processes of tegumen; sa, sacculus; sc, saccus; t, tegumen; u, uncus; v, vinculum; vi, vitta. Unless otherwise stated the views of the genitalia (A) are from the lateral aspect, those of the harpes (B) are from within, and those of the tegumen (C) central ones.)

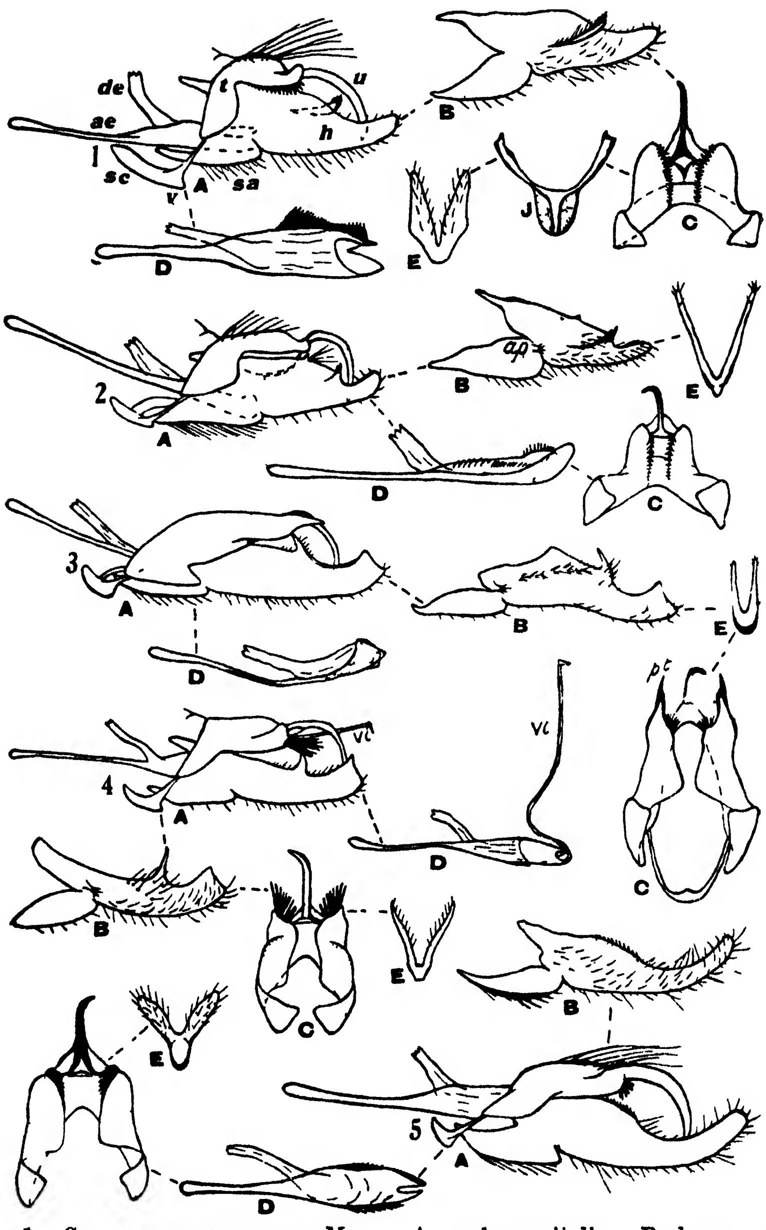


FIG. 1.—*Carposina gonosemana* Meyr. A, male genitalia. B, harpe. C, tegumen. D, aedeagus, dorsal view. E, juxta. J. vinculum.
FIG. 2.—*C. contactella* Walk. A, male genitalia. B, harpe. C, tegumen. D, aedeagus, lateral view. E, Juxta.
FIG. 3.—*C. iophaea* Meyr. A, male genitalia. B, harpe. C, tegumen and vinculum. D, aedeagus, lateral view. E, juxta.
FIG. 4.—*C. charaxias* Meyr. A, male genitalia. B, harpe. C, tegumen. D, aedeagus, dorsal view. E, juxta.
FIG. 5.—*C. exochana* Meyr. A, male genitalia. B, harpe. C, tegumen. D, aedeagus, dorsal view. E, juxta.

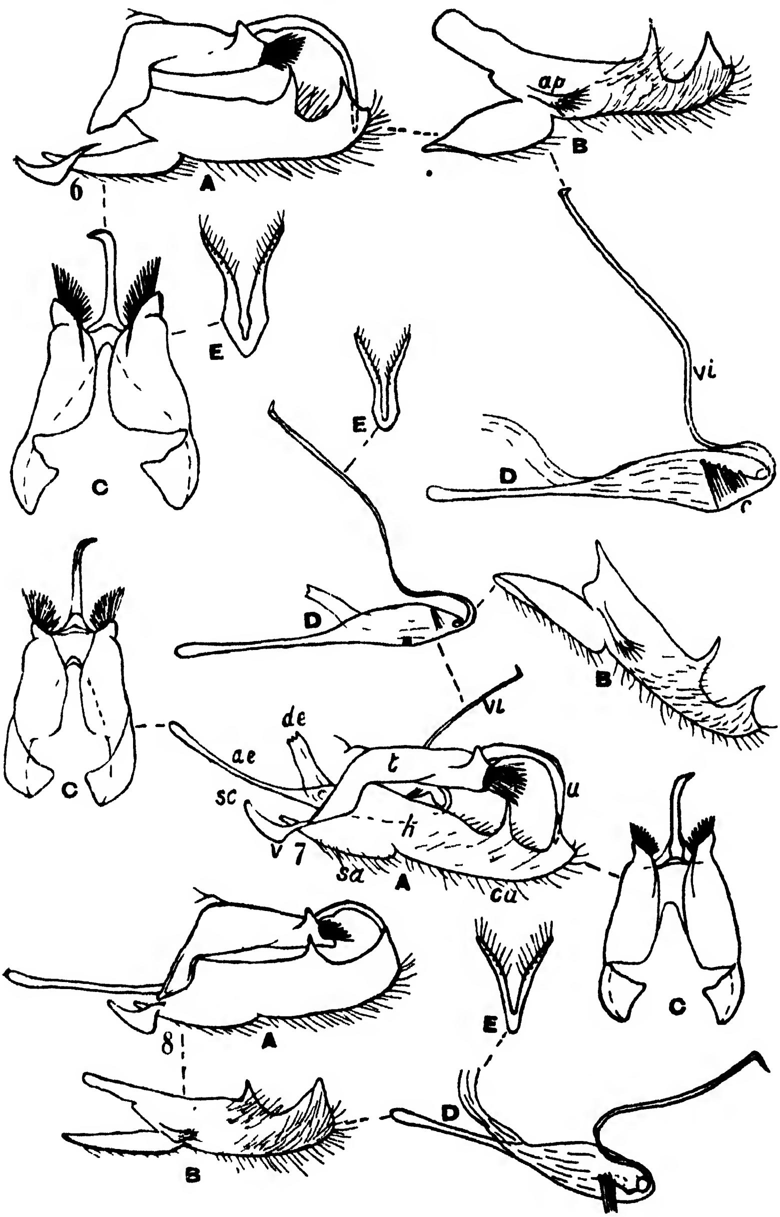


FIG. 6.—*C. epomiana* Meyr. A, male genitalia. B, harpe. C, tegumen. D, aedeagus, dorsal view. E, juxta.
FIG. 7.—*C.* n. sp. A, male genitalia. B, harpe. C, tegumen. D, aedeagus, dorsal view. E, juxta.
FIG. 8.—*C. cryodana* Meyr. A, male genitalia. B, harpe. C, tegumen. D, aedeagus, dorsal view. E, juxta.

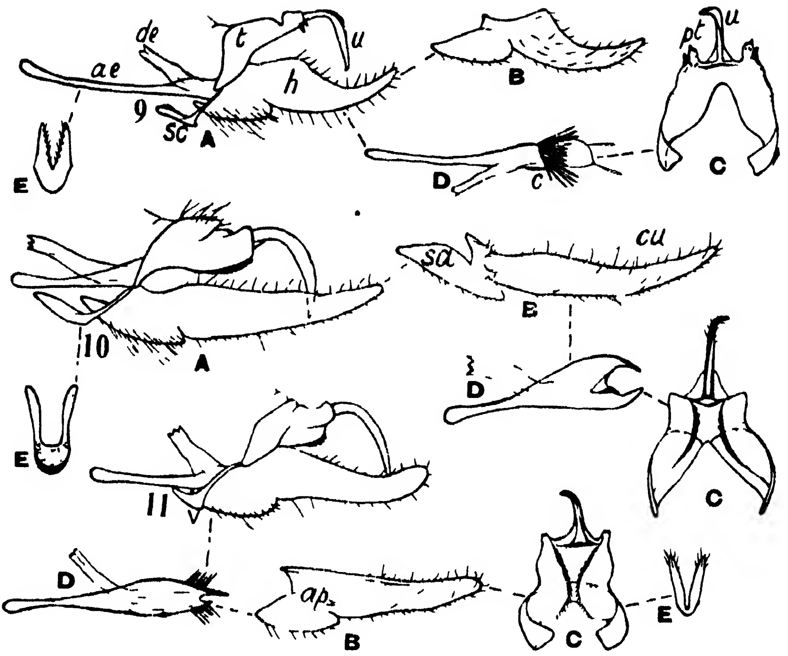


FIG. 9.—*C. adreptella* Walk. A, male genitalia. B, harpe. C, tegumen. D, aedeagus, dorsal view. E, juxta.
FIG. 10.—*C. enphylla* Meyr. A, male genitalia. B, harpe. C, tegumen. D, aedeagus, dorsal view. E, juxta. J, vinculun.
FIG. 11.—*C. maculosa* Philp. A, male genitalia. B, harpe. C, tegumen. D, aedeagus, dorsal view. E, juxta.

Notes and Descriptions of New Zealand Lepidoptera.

By ALFRED PHILPOTT, Hon. Research Student in Lepidoptera, Cawthron Institute, Nelson.

[*Read before the Nelson Philosophical Society, 12th September, 1928; received by Editor, 25th September, 1928; issued separately, 16th November, 1928.*]

Erebia merula Hew., *Ent. Mo. Mag.*, 12, 10 (1875); *Oreina othello* Fered., *Trans. N.Z. Inst.*, 8, 302 (1876).

OUR largest *Erebia* is commonly known as *E. pluto* Fereday, but a study of the literature shows that its proper name is *E. merula* Hewitson. In a paper entitled "Observations on a Paper read by Mr. A. Bathgate before the Otago Institute, 11th January, 1870, 'On the Lepidoptera of Otago'" (*Trans. N.Z. Inst.*, 4, 214 (1872), Fereday writes as follows, "I may also mention a black butterfly found on the bare summits of the snowy mountains. . . . I believe it to be a species of *Erebia* and have named it *E. pluto.*" These remarks do not constitute anything more than casual mention and the single word "black," especially in the absence of a figure, cannot be termed a description. Four years later (*Trans. N.Z. Inst.*, 8, 302), Fereday published a very full description of the butterfly, accompanied by a figure, which bore the legend "*Oreina othello* n. sp.," the alteration in the name originally proposed being accounted for by "pluto" being preoccupied. In the meantime, however, Hewitson, the British lepidopterist, had received an example of the species from Herman Strecker of Pennsylvania and had described it as *E. merula* in the *Ent. Mo. Mag.* for June, 1875 (p. 10), thus antidating Fereday's *othello* by nearly a year. In December, 1876, Butler published an article on the butterflies of New Zealand in the *Ent. Mo. Mag.* (vol. 13, p. 152) and adopted the name "pluto," giving as a reason for discarding Hewitson's* *merula* that "although Mr. Fereday only describes this species as black, not mentioning the ocelli, his name will have to stand, since there is no other black *Erebia* in New Zealand." Butler, it should be noted, does not give the reference to "pluto" but a full reference to *othello*, a circumstance which seems to indicate that he regarded the actual describing of the species to date from 1876; and it is the date of such description which alone matters. I do not think there is any reading of the *International Rules* which could be interpreted as validating a specific name supported only by the words "I may also mention a black butterfly."

LYCAENIDAE.

Chrysophanus feredayi Bates, *Ent. Mo. Mag.*, 4, 53 (1867); *C. enysii* Butler, *Ent. Mo. Mag.*, 13, 153 (1876).

Owing apparently to some confusion on the part of A. G. Butler the name *enysii* has been commonly adopted for Bates's *feredayi*. At

*Butler gives the year 1874 as the date of Hewitson's paper; it should be 1875.

the reference quoted above Bates described his species as differing, among other characters, from *C. edna* (a synonym of *C. sallustius* Fabr.) by the colour of the undersides of the hindwings, which he stated were "yellow, with a broad curved discal patch and a wide posterior border (confluent at the apex) violet-brown." Nine years afterwards Butler (see above reference) described *enysii,* but his description seems to be only an amplification of Bates's diagnosis of *feredayi,* a species he treats as separate without further comment. Fereday, who had supplied Bates with the type material, published a paper in 1878 (*Trans. N.Z. Inst.,* 10, 252) in which he figured upper and under sides of *C. feredayi,* the drawings, though uncoloured, quite satisfactorily showing the characteristic markings. In the same volume (p. 263) Butler had an article in which he redescribed and figured his *enysii* as well as Bates's *feredayi.* These figures show that he had confused the species. Figures 4, 5 and 6 (pl. 12) represent *C. enysii*; 4 is apparently a dark specimen of *C. sallustius* Fabr., 5 is the unmistakable underside of *feredayi,* while 6 is the upper-side of the same species. Figures 7, 8 and 9 are devoted to *C. feredayi.* But none of them at all agrees with Bates's description; it is impossible to reconcile the markings of either upper or under-sides with the characters as given by the describer of the species. A further point which strengthens the conclusion arrived at above is that Butler describes *feredayi* as having "the whole ground colour of the secondaries brown," a statement directly at variance with Bates's description. As a matter of fact there is a race of *sallustius* in which the undersides of the hindwings are uniformly brown, the upper-surfaces of the forewings being much darker than in the typical form. It seems not improbable that Butler founded his *enysii* on an example of this race (which may ultimately prove to be a good species) and a specimen of the true *feredayi.* It should be noted that Longstaff (*Trans. N.Z. Inst.,* 44, 115) pointed out that Bates's name had priority and that the types, which are in the British Museum, were clearly conspecific.

I found *C. feredayi* very abundant in a lowlying piece of mixed forest on the shores of Lake Rotoroa. This was early in January, and the specimens were all in fresh condition.

NOCTUIDAE.

Ectopatria aspera (Walk.), *Cat.,* 11, 601 (1857); *E. provida* (Walk. *Cat.,* 15, 1737 (1858); *E. canescens* (Walk.), *Cat.,* 33, 757 (1865).

It is 70 years since Walker described his *provida,* the specimen being from Auckland. Seven years later he named another Auckland specimen of the same species, *canescens.* Both these names are, however, synonyms of his *aspera,* an Australian species described in 1857. As far as I am aware, no specimens of *aspera* have been captured since the Auckland examples were secured, but I have now to record the taking of 3 males and 3 females at Nelson during the past season. Three of these were secured by Mr. E. Gourlay and the others by myself, the dates of capture ranging from the last week in October to the third week in March.

I am indebted to Mr. Meyrick for the determination of the species and for full information as to the synonymy. The species has been described and figured by Hampson (*Cat. Lep. Phal. B.M.*, 4, 654, pl. 77, 27). A brief diagnosis is given below.

♂ ♀. 36-38 mm. Forewings and thorax whitish-grey; basal, 1st and 2nd lines obscure, waved, interruptedly margined with black; stigmata margined with black; claviform elongate, orbicular round or oval, reniform constricted at middle; two or three black dashes in centre of suterminal area. Hindwings in ♂ white with broad fuscous area round apex and termen; in ♀ wholly fuscous.

The ♂ has a dense truncate tuft of hair on the middle tibia, a character which Hampson seems to have overlooked.

Aletia mitis (Butl.), *Proc. Zool. Soc. Lond.*, 1877, p. 383, pl. 42, 5; *Aletia gourlayi* Philp., *Trans. N.Z. Inst.*, 53, 337.

After re-examination of the type of *gourlayi* (now in the Canterbury Museum) I believe the above correction to be necessary.

Aletia dentata Philp., *Trans. N.Z. Inst.*, 54, 148.

In his recent finely illustrated monograph, *The Butterflies and Moths of New Zealand,* Hudson treats this species as a synonym of *A. cuneata* Philp. I am unable at present to accept this emendation, *dentata* being a smaller and darker insect than *cuneata* and, indeed, superficially more nearly approaching *panda* Philp. Unfortunately, no male of *dentata* has been available for genitalia examination.

Melanchra pictula (White), *Te Ika a Maui,* pl. 1, 3 (1855); *M. rhodopleura* (Meyr.), *Trans. N.Z. Inst.*, 19, 19 (1887); *M. rhodopleura* Huds., *N.Z. M. and B.*, p. 19, pl. 4, 38; *M. rhodopleura* Sunley, *Trans. N.Z. Inst.*, 43, 129; *M. rhodopleura* Meyr., *Trans. N. Z. Inst.*, 44, 100; *M. rhodopleura* Huds., *B. and M. N.Z.*, p. 63, pl. 7, 32.

M. meyricci (Hamps.), *Ann. and Mag. Nat. Hist.*, (8), 8, 421 (1911); *M. pictula* (Butl.) *nec* White, *Proc. Zool. Soc. Lond.*, 1877, 386, pl. 42, 1; *M. pictula* (Meyr.) *nec* White, *Trans. N.Z. Inst.*, 19, 18; *M. pictula* Huds. *nec* White, *N.Z. M. and B.*, p. 19, pl. 4, 37; *M. pictula* Ham. *nec* White, *Trans. N.Z. Inst.*, 43, 117 and 119; *M. pictula* Meyr. *nec* White, *Trans. N.Z. Inst.*, 44, 100; *M. pictula* Huds. *nec* White, *B. and M. N.Z.*, p. 63, pl. 7, 33.

The synonymy of these two species hinges on which form White's figure refers to. There cannot be the least doubt that the figure represents the species without the white reniform and with the wholly fuscous hindwings, that is, the *rhodopleura* of Meyrick. Longstaff (*Trans. N.Z. Inst.*, 44, 110) indicated the correct nomenclature, but did not refer to the synonymy of the two species, and the majority of New Zealand collectors still use the erroneous names.

M. furtiva Philp., *Trans. N.Z. Inst.*, 55, 663.

Hudson (*B. and M. N.Z.*, p. 66) treats *furtiva* as a variety of *M. mutans* Walk., remarking that "specimens of the female (of *mutans*) from high altitudes are often more silvery than those from the lowlands and this form has been recently described . . . . under the name of *Melanchra furtiva.*" It is, however, the male of *furtiva* which differs most from *mutans*; the female is often only separable with difficulty. Apart from the ground-colour of the forewings in the males—in *mutans* dull brown tinged with reddish or ochreous, in *furtiva* clear pinkish-brown—there are good structural differences in the antennae, *furtiva* having the ciliations appreciably longer than *mutans*. The harpes (valvae) of the two species are figured in *Trans. N.Z. Inst.*, 55, 665, and it will be seen that here also the structural differences are sufficiently marked.

HYDRIOMENIDAE.

Hydriomena praerupta Philp., *Trans. N.Z. Inst.*, 50, 125.

Hudson (*B. and M. N.Z.*, p. 100) considers this to be a variety of *H. callichlora* Butl. The species are certainly much alike superficially and it is not easy to pick out definite distinguishing characters, but when series of each are compared the difference of facies is apparent. The male genitalia, for the most part, exhibit only slight differences, but the shape of the tegumen, as viewed from above, is sufficiently striking; the absence of a chitinized gnathos in *callichlora* and the strong basal chitinization of the organ in *praerupta* is also conclusive for specific separation (see Figs. 1 and 2).

Xanthorhoe eupitheciaria Guen., *Ent. Mo. Mag.*, 5, 95.

Referred by Hudson (*B. and M. N.Z.*, p. 113), with some doubt, to *X. cinerearia* Dbld. Examination of the male genitalia shows that the species is more widely separated from *cinerearia* than from *X. semisignata* Walk. and *X. plumbea* Philp. (see Figs. 3, 4, 5 and 6).

X. obscura Philp., *Trans. N.Z. Inst.*, 53, 338.

Originally I described this form as a subspecies of *X. helias* Meyr., but I am now prepared to admit it to full specific rank

Notoreas zopyra Meyr., *Trans. N.Z. Inst.*, 16, 89.

Hudson (*M. and B. N.Z.*, p. 126) has united this with *N. brephos* Walk., at the same time very accurately pointing out the distinctions between the two forms. The male genitalia, however, show many pronounced differences. The uncus is apically blunt in *brephos*, sharp in *zopyra*; the lobes of the juxta (cristae) are quite different in the two species, while the harpes (see Figs. 7 and 8) exhibit several distinguishing features.

Dasyuris austrina Philp., *Trans. N.Z. Inst.*, 58, 359.

An excellent figure of this species (as a var. of *D. hectori* Butl.) is given by Hudson (*B. and M. N.Z.*, pl. 15, 20).

SELIDOSEMIDAE.

Selidosema fluminea Philp., *Trans. N.Z. Inst.*, 56, 389; *S. productata* Walk. var., Huds., *B. and M. N.Z.*, p. 139, pl. 48, 26.

Both *productata* and *fluminea* are subject to considerable variation, but I have not met with any examples which could not be referred to one or the other species without hesitation. The antennal pectinations of *fluminea* are slightly shorter than those of *productata* and the male genitalia offer good distinguishing features (see Figs. 9, 10, 11 and 12).

PHYCITIDAE.

Homoeosoma farinaria Turner, *Proc. Roy. Soc. Q.* (1903) 128.

I am indebted to Dr. A. Jefferis Turner for the determination of this species, which has long been confused (in New Zealand) with *H. vagella* Z. Dr. Turner informs me that though originally described from Tasmania it occurs also in Queensland and New South Wales. In New Zealand the species is not uncommon, though apparently somewhat local. It has been taken in both Islands and records extend from Invercargill in the South to Cambridge in the North. It is seldom found by day, but is a frequent visitor to lighted windows. under which circumstances it occurs from early November to the beginning of May. Recently the moth has been bred out freely in the Cawthron Insect Laboratory from larvae found feeding on the ragwort (*Senecio Jacobaea*) at Cambridge, N.I. The true *vagella* Z., which is a smaller and more obscure insect, is comparatively rare, though it has been known to occur in New Zealand for about 30 years.

PTEROPHORIDAE.

Platyptilia indubitata new name.

I propose the above name for *P. ferruginea* Philp. (*Trans. N.Z. Inst.*, 54, 150) preoccupied by *ferruginea* Walshingham *Trans. Ent. Soc. Lond.*, 1897, p. 35). Hudson (*B. and M. N.Z.*, p. 207) considers *indubitata* to be a synonym of *falcatalis* Walk., but apart from coloration, the species are easily distinguished by structural characters. In *falcatalis* there is always a prominent tooth of black scales in the fringes of the forewings at $\frac{3}{5}$ and a similar patch in the hindwings just beyond the middle; these scale-patches are not present in *indubitata*.

Platyptilia pulverulenta Philp., *Trans. N.Z. Inst.*, 54, 149.

This species is also treated by Hudson (at previous reference) as a synonym of *falcatalis*; it differs, however from that species in the same way as does *indubitata*. It is possible, however, that *pulverulenta* and *indubitata* are the same species, in which case *pulverulenta* has page priority.

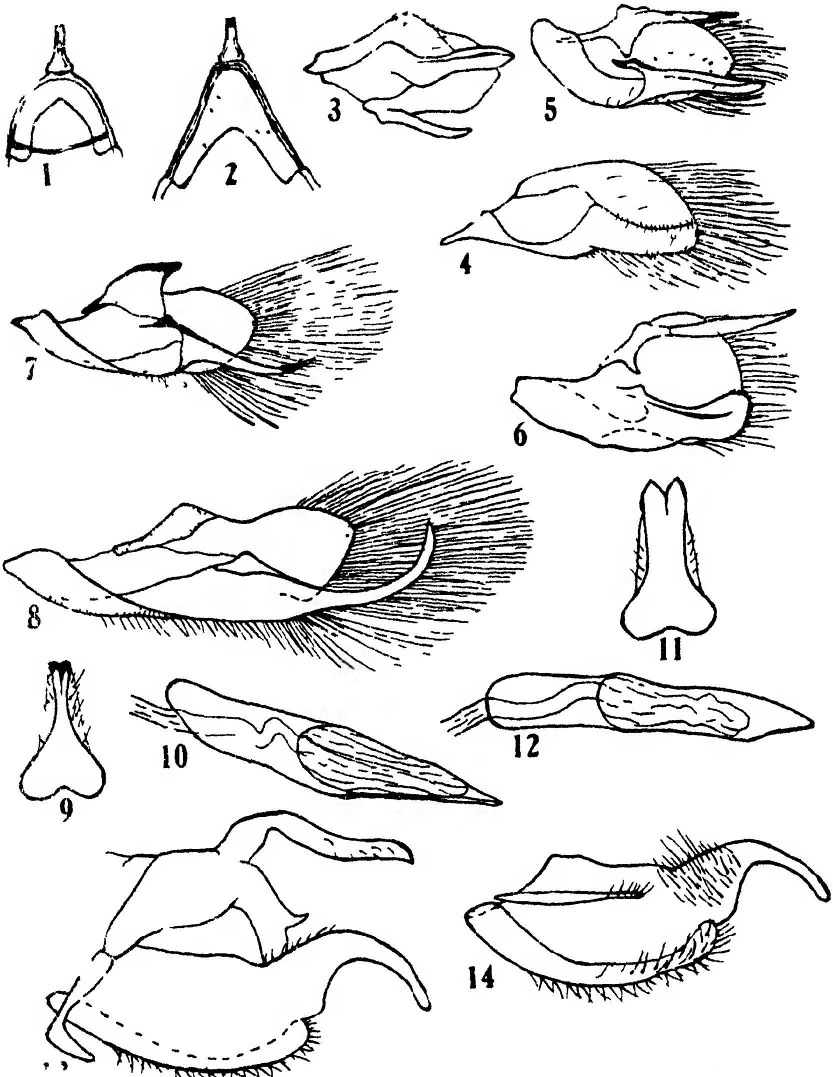


FIG. 1.—*Hydriomena praerupta* Philp Dorsal view of upper part of tegumen.
FIG. 2.—*H. callichlora* Butl. Dorsal view of upper part of tegumen.
FIG. 3.—*Xanthorhoe eupitheciaria* Guen. Harpe, from within.
FIG. 4.—*X. cinerearia* Dbld. Harpe, from within.
FIG. 5.—*X. plumbea* Philp. Harpe, from within
FIG. 6.—*X. semisignata* Walk. Harpe, from within.
FIG. 7.—*Notoreas zopyra* Meyr Harpe, from within.
FIG. 8.—*N. brephos* Walk Harpe, from within
FIG. 9.—*Selidosema fluminea* Philp Juxta.
FIG. 10.—*Selidosema fluminea* Philp. Aedeagus.
FIG. 11.—*S. productata* Walk. Juxta.
FIG. 12.—*S. productata* Walk. Aedeagus
FIG. 13.—*Borkhausenia sinuosa* Philp. Male genitalia, lateral view.
FIG. 14.—*Borkhausenia sinuosa* Philp. Harpe, from within.

TORTRICIDAE.

Epichorista fraudulenta (Philp.), *Trans. N.Z. Inst.*, 58, 363.
Originally described as an *Eurythecta.*

E. abdita Philp., *Trans. N.Z. Inst.*, 55, 664.
Considered by Hudson (*B. and M. N.Z.*, p. 238) to be a synonym of *E. emphanes* Meyr. Reference to the figures of the male genitalia (*Trans. N.Z. Inst.*, 55, 665) will show markedly different structural peculiarities.

Tortrix incendiaria (Meyr.), *Trans. N.Z. Inst.*, 54, 164.
As intimated in "The Male Genitalia of the New Zealand Tortricidae" (published elsewhere in this volume) I propose the removal of this species from *Ecclitica* to *Tortrix.*

Gelophaula vana n. sp.
♂. 26-29 mm. Superficially extremely like *G. siraea* Meyr., but a larger and less bright insect. The yellow median stripe of the forewings is not so bright as in *siraea* and tends to be more suffused, not infrequently occupying nearly all the lower half of the wing. The fringes of the hindwings are usually yellowish tinged, not white as in *siraea.*
♀. 29-32 mm. Forewings pale yellow sprinkled with fuscous, the venation clearly marked in a paler tint. Hindwings white, dusted with grey except apically.
Hunter Mountains. Abundant at about 4,000 feet in December and January. For figures of the male genitalia see an article in this volume dealing with the New Zealand Tortricidae. Holotype (♂), allotype (♀) and a series of paratypes in coll. Cawthron Institute.

Ecclitica torogramma (Meyr.), *Trans. Ent. Soc. Lond.*, 1897, 388.
Reference to an article on the male genitalia of the Tortricidae, to be found elsewhere in this volume, will show that I have thought it necessary to transfer this species from *Tortrix* to its present position.

Cnephasia fastigata Philp., *Trans. N.Z. Inst.*, 48, 442.
Originally described as a *Tortrix*; I now place it in this genus.

EUCOSMIDAE.

Raumatia n. g.

Antennae in male minutely ciliated. Palpi moderate, second segment thickened with scales above and beneath, terminal segment short. Thorax without crest. Forewings, in male with costal fold; smooth; termen very oblique; 3, 4, 5 equidistant at origin, 11 from before middle of cell, 10 much nearer 9 than 11 (in *trimaculata* only slightly). Hindwings with 7 veins, 5 absent, 6 and 7 approximated towards base, cubital pecten very slight. Male genitalia with harpes

large, neck incurvation strong, spines absent or very small; uncus feeble, simple or bifid; socii plate-like; gnathos absent; aedeagus rather small, nearly straight, apex scoop-shaped.

Genotype.—*Eurythecta potamias* Meyrick.

The genus is erected for the reception of the following three species.

R. potamias (Meyr.), *Trans. N.Z. Inst.*, 41, 11.

R. varia (Philp.), *Trans. N.Z. Inst.*, 48, 421.

R. trimaculata (Philp.), *Trans. N.Z. Inst.*, 47, 198.

The last-named species does not well agree with the others generically and it may yet have to be separated therefrom.

OECOPHORIDAE.

Borkhausenia xanthodesma Philp., *Trans. N.Z. Inst.*, 54, 151.

A species treated by Hudson (*B. and M. N.Z.*, p. 261) as a synonym of *B. compsogramma* Meyr. There can, however, be no doubt as to the distinctness of the two, the male genitalia being widely different (see Figs., *Trans. N.Z. Inst.*, 56, *xanthodesma* p. 409, *compsogramma* p. 410).

B. melanamma Meyr., *Trans. Ent. Soc. Lond.*, 1905, 240.

Under this species Hudson includes, with a query, *B. sabulosa* Philp. and *B. terrena* Philp. There is little doubt as to the validity of *terrena* (compare genitalia figures of *terrena*, (*Trans. N.Z. Inst.*, 56, 392) with those of *melanamma* (*ib.* 56, 412). In the case of *sabulosa* no examination of the genitalia has been made, but the species is superficially unlike *melanamma.*

B. sinuosa n. sp.

♂. 17-19 mm. Head and thorax clear yellow. Palpi yellow, second segment mixed with fuscous without. Antennae greyish-fuscous, ciliations in ♂ ½. Abdomen greyish-white, anal tuft ochreous. Legs ochreous-white, anterior pair strongly infuscated. Forewings elongate, costa well arched, apex rounded, termen obliquely rounded; clear yellow; costa at base narrowly edged with brown; fringes concolorous with wing. Hindwings and fringes whitish-grey.

Superficially hardly separable from *B. enodis* Philp., though the costa is rather more arched and the apex more rounded. The male genitalia, fortunately, offer good differentiating characters, the shape of the uncus being, as far as I am aware, unique among New Zealand members of the genus (see Figs. 13 and 14 of this article for *sinuosa* and *Trans. N.Z. Inst.*, 58, 85, Fig. 3, for *enodis.*

Wellington, in December. Two males taken in the Botanical Gardens. Holotype (♂), paratype and a slide of male genitalia in coll. Cawthron Institute.

Locheutis pulla n. sp.

♂. 13-14 mm. Head fuscous, neck ochreous. Palpi fuscous, second segment mixed with ochreous. Antennae fuscous, ciliations

in ♂ 2. Thorax bronzy-fuscous. Abdomen leaden-fuscous, bronzy-fuscous dorsally. Legs leaden-fuscous mixed with ochreous, tarsi obscurely annulated with ochreous. Forewings moderate, costa moderately arched, apex obtuse, termen oblique; brownish-fuscous; costal edge ochreous; stigmata obscure or absent, plical at about ½: fringes concolorous with wing. Hindwing fuscous, fringes paler.

A darker species than *vagata* Meyr. and at once distinguished by the shorter antennal pectinations.

One male taken at Lake Rotoroa about the middle of January and two others secured on Mount Cedric at an elevation of 4,000 ft. Holotype (♂), paratypes and a slide of male genitalia in coll. Cawthron Institute.

PLUTELLIDAE.

Protosynaema matutina n. sp.

♂. 10 mm. Head and thorax purplish-brown. Palpi ochreous white. Antennae purplish-brown with some white scales, in ♂ strongly thickened with scales, to near apex. Abdomen greyish-fuscous. Legs purplish-fuscous, tarsi annulated with white. Forewings with costa moderately arched, apex rectangular, termen slightly rounded, oblique; purplish-fuscous mixed with bright brown and purplish-white; a broad metallic green striga from costa near base, outwardly oblique and reaching to fold, anteriorly and posteriorly broadly margined with dark purplish-fuscous; a similar striga at ½, reaching across wing, outwards curved, anteriorly broadly margined with bright brown mixed with black on median portion, posteriorly more narrowly margined with bright brown; an irregular striga of same colour from tornus to middle of wing, margined with brown; a metallic green line round termen, anteriorly margined with blackish: fringes bright brown. Hindwings greyish-fuscous, darker apically; fringes greyish-fuscous.

Differs structurally from *P. steropucha* Meyr. in the unindented termen of the forewing and from *P. quaestuosa* Meyr. in the much more extensive thickening of the antennae.

Mount Arthur Tableland, early in November. A single male taken at about 4,500 ft. Holotype in coll. Cawthron Institute.

TINEIDAE.

Archyala opulenta Philp., *Trans. N.Z. Inst.*, 56, 398.

Considered by Hudson (*B. and M. N.Z.*, p. 341) to be identical with *A. terranea* Butl. The resemblance between the two is fairly close, but the male genitalia disprove specific identity (see Figs. *Trans. N.Z. Inst.*, 58, 94).

Mallobathra angusta n. sp.

♂. 20 mm. Head and palpi tawny. Antennae brown mixed with ochreous, ciliations in ♂ 2. Thorax and abdomen purplish-brown. Legs purplish-brown mixed with ochreous, tibiae and tarsi annulated with ochreous. Forewings elongate, narrow, costa moder-

ately arched, apex rounded, termen strongly oblique; ochreous; strigulated throughout with dark purplish-fuscous; a blotch of purplish-fuscous on costa at middle and a similar one on dorsum beneath; fringes fuscous-grey. Hindwings dark fuscous; fringes fuscous-grey, paler apically.

The largest of the genus yet described. The long but narrow wings sufficiently separate it from any other species.

A single male taken in November at about 3,000 ft. on the Mount Arthur Tableland track. Holotype in coll. Cawthron Institute.

M. strigulata Philp., *Trans. N.Z. Inst.*, 55, 214.

This species is considered by Hudson (*B. and M. N.Z.*, 352) to be synonymous with *M. crataea* Meyr. The members of the genus are often superficially much alike, but in the case under consideration there exist good genitalia characters for differentiation (see Figs., *Trans. N.Z. Inst.*, *crataea,* p. 98, *strigulata,* p. 100). *M. fenwicki* Philp. (*ib.* 55, 214) is also treated by Hudson (same reference) as equal to *crataea,* but in this instance material for dissection has not been available. I should, however, consider this form to be more nearly related to *M. homalopa* Meyr. than to *crataea.*

MNESARCHAEIDAE.

Mnesarchaea similis Philp., *Trans. N.Z. Inst.*, 55, 667.

This species is treated by Hudson (*B. and M. N.Z.*, p. 367) as a synonym of *M. hamadelpha* Meyr., but as noted in the original description of *similis,* there are good differentiating characters in the male genitalia. The colour and markings of the two forms, though similar, are by no means identical. The basal fuscous stripe on the costa of the forewing is apically pointed in *hamadelpha,* but blunt or suffused in *similis*; also, the thorax is ochreous in *similis,* white in *hamadelpha.* For figures of the genitalia see *Trans. N.Z. Inst.*, 55, 666 and *ib.* 57, 714, pl. 57, 22 and 23. It is possible, however, that *similis* Philp. may really be *hamadelpha* Meyr. which would leave the insect usually regarded as that species without a name. Steps will be taken to ascertain the position.

Sixth Supplement to the Uredinales and Ustilaginales of New Zealand.

By G. H. CUNNINGHAM, Mycologist, Plant Research Station, Palmerston North, New Zealand.

[*Read before the Wellington Philosophical Society, 27th June, 1928; received by Editor, 15th August, 1928; issued separately, 23rd November, 1928.*]

RECENTLY, through the courtesy of Mr. W. R. B. Oliver, Acting-Director of the Dominion Museum, I was able to examine for the presence of Rust and Smut Fungi, the large number of New Zealand flowering plants in the Petrie Herbarium, now placed in the Dominion Museum, Wellington. From this large collection, surprisingly few fungi were obtained, about one hundred species in all, only one of which was undescribed.

Early this year I was enabled to make an extensive collecting tour through the provinces of Otago, Canterbury, Westland and Nelson, accompanied by Dr. H. H. Allan, Botanist to the Plant Research Station. Together we succeeded in obtaining approximately 600 collections of Rusts and Smuts, belonging to 78 species Of these 18 were either undescribed or hitherto unrecorded for New Zealand.

The object of this paper is to present descriptions of these species, together with additional hosts, collected on this tour, or obtained from the Petrie Herbarium. Several additional stages of already described species have also been collected, necessitating one or two corrections in matter already published.

I am indebted to Dr. Allan for naming the hosts of all the collections obtained, and for the numerous collections he made for me during the tour.

UREDINALES.

***1. Puccinia arnaudensis** n. sp. JUNCACEAE.

O. Unknown.

II. Uredosori erumpent, scattered, bullate, pulverulent, ferruginous, elliptical, 1 mm. diam. Spores shortly elliptical or obovate, 35-40 x 22-25 mmm.†; epispore pallid ferruginous, 1.5-2 mmm. thick, except at the apex where thickened to 6 mmm. and deeper in colour, finely and densely echinulate; germ pores inevident.

III. Teleutosori erumpent, scattered, elliptical, 1-4 mm. long, bullate, pulverulent, chestnut-brown, surrounded by the ruptured epidermis. Spores subclavate or elliptical, 28-48 x 17-24 mmm.; apex rounded, not or scarcely thickened, base attenuate, less commonly rounded, basal cell larger and slightly narrower; not or slightly

*Illustrations of these species will be presented in a book on the New Zealand Uredinales, now in the course of preparation.

†mmm: abbreviation used for micron.

constricted at the septum; epispore chestnut-brown, 2 mmm. thick, finely and sparsely verrucose; pedicel deciduous, hyaline, fragile, to 20 x 6 mmm.; germ pore of the upper cell apical or less frequently ⅓ towards septum, basal pore immediately above the pedicel or between the septum and the pedicel, both conspicuous and occasionally papillate.

X. Mesospores rare, elliptical or obovate, 26-32 x 16-20 mmm.

Host: *Rostkovia gracilis* Hook. f.

Mt. St. Arnaud, Nelson, 1,800 m., 2/28. *H. H. Allan!* Type.

The host is endemic and confined to the mountain regions of the South Island (Cheesem. 1925, p. 291).

This species differs from *P. Rostkoviae* Speg. on *Rostkovia grandiflora* in South America, in the epispore of the teleutospore being verrucose, not smooth, and in the absence of paraphyses and presence of uredospores.

2. **Puccinia Grahami** n. sp. UMBELLIFERAE.

O. Pycnia amphigenous, conspicuous, scattered, associated with the aecidia, flask-shaped, semi-erumpent.

I. Aecidia amphigenous, chiefly epiphyllous, scattered evenly over the central parts of the leaf, and on petioles, seated on yellow spots; peridia 0.3-0.4 mm. diameter, cylindrical, standing above the leaf surface 1 mm., eroded, but not lacerate. Spores subglobose or shortly elliptical, 20-24 mmm.; epispore hyaline, 1 mmm. thick, minutely and densely verruculose.

III. Teleutospores amphigenous, compacted into dense linear series, 15 cm. or more in length, individual sori erumpent, elliptical, 0.5-1 mm. long, pulverulent, long covered. Spores elliptical or subclavate, irregular, 40-52 x 20-24 mmm; apex rounded, seldom bluntly acuminate, not or scarcely thickened, base acuminate, basal cell longer and narrower, cuneiform; slightly constricted at the septum; epispore delicately verruculose, chestnut-brown, 1.5-2 mmm. thick; pedicel deciduous, hyaline, to 25 x 6 mmm; germ pore of the upper cell apical or ⅓ towards the septum, basal pore ⅓ to ⅔ below the septum, both conspicuous and papillate.

X. Mesospores common, obovate or fusoid, 35-48 x 20-24 mmm.

Hosts: *Aciphylla Monroi* Hook. f.

Sealey Lake, Mt. Cook, Canterbury, 1,500 m. 1/28. *H. H. Allan!* Type.

Mt. Trovatore, Westland, 1,200-1,500 m. 2/28. *G.H.C.*

Aciphylla Monroi x *Colensoi*.

Sealey Lake, Mt. Cook, Canterbury, 1,500 m. 1/28. *H. H. Allan!*

Both hosts are endemic, the former being confined to the mountain regions of the South Island (Cheesem. 1925, p. 665).

This species is peculiar in that in a considerable number of the teleutospores there may be two germ pores in the cell. For example, there may be two pores in the upper, and one in the lower cell; or two in the lower but one in the upper cell; but in no case has two pores in each cell been noted.

The rust is named in honour of Mr. Peter Graham, the well-known guide, for many years at Mt. Cook, now manager of Waiho

House, Franz Josef Glacier; to whom Dr. Allan and myself are indebted for a very interesting and profitable tour of the mountains in the region of the Franz Josef Glacier.

3. **Puccinia Kinseyi** n. sp.

O. Unknown.

I. Aecidia hypophyllous, when aggregated into small groups, and caulicolous when crowded on inflated, sometimes distorted areas which may attain a length of 25 mm. or more, and on fruits when scattered evenly over the carpels; peridia cupulate, 0.3-0.5 mm. diam., apex slightly erumpent, expanded but not revolute, lacerate when old. Spores subglobose or polygonal, 18-24 mmm. diam.; epispore hyaline, 1 mmm. thick, finely and densely verruculose.

II. Uredosori hypophyllous, scattered, orbicular, 0.5 mm. diameter, pulverulent, pallid brown, partly covered by the ruptured epidermis. Spores obovate or subglobose, 22-28 x 20-25 mmm.; epispore tinted lemon yellow, 1.5 mmm. thick, finely and rather sparsely echinulate; germ pores equatorial, 4, conspicuous.

III. Teleutosori similar to the uredosori but chestnut-brown. Spores elliptical or subclavate, 28-35 x 18-24 mmm.; apex rounded, not thickened, base rounded, basal cell slightly narrower; slightly constricted at the septum; epispore smooth, 2 mmm. thick, chestnut-brown; pedicel deciduous, hyaline, to 35 x 8 mmm.; germ pore of the upper cell apical, basal pore immediately above the pedicel, both often papillate and conspicuous.

Host: *Angelica geniculata* (Forst. f.) Hook. f.

Raikaia Gorge Island, Canterbury, 400 m. 1/28. *H. H. Allan!* Type.

The host is endemic and occurs in both Islands (Cheesem. 1925, p. 683). This species resembles most closely *P. Anisotominis* G. H. Cunn. on *Anisotome Haastii*, but is separated from this species in that the apices of the aecidiospores are not thickened, and by the much smaller teleutospores, those of *P. Anisotominis* being 40-60 x 17-22 mmm.

The rust is named in honour of Sir Joseph Kinsey, a staunch supporter of New Zealand botanical research.

4. **Puccinia keae** n. sp. COMPOSITAE.

O. Unknown.

III. Teleutosori scattered, hypophyllous, orbicular, 0.5-1 mm. diam., pulverulent, orange or pallid chestnut-brown, naked but covered by the tomentum of the leaf. Spores linear-oblong, or subclavate, 80-144 x 20-30 mmm.; apex rounded or less frequently slightly subacuminate, not thickened, base subattenuate, lower cell longer and narrower than the upper, usually cuneiform; constricted at the septum; epispore 1 mmm. thick, tinted, almost hyaline, smooth; contents orange yellow; pedicel persistent, hyaline, length of the spore; germ pore of the upper cell apical, basal pore immediately beneath the septum, both obscure.

Host: *Olearia nummularifolia* Hook. f.

Kea Point, Mt. Cook, Canterbury, 700 m. 1/28. *H. H. Allan-G.H.C.* Type.

The host is endemic and occurs in both Islands (Cheesem. 1925, p. 924).

The rust is very close to *P. hectorensis* G. H. Cunn. on *Senecio Bidwillii,* but differs in the thinner, tinted epispore, and slightly different shape of the teleutospore. The absence of an aecidium may also be a diagnostic character, but in the absence of pycnia it cannot be stated definitely that an aecidium does not occur in the cycle of the species under consideration.

The teleutospores germinate immediately on reaching maturity, giving to the sori a distinct orange colour.

5. **Puccinia perlaevis** n. sp.

O. Pycnia in small, scattered, epiphyllous, orbicular groups seated on discoloured spots, immersed.

I. Aecidia orange, in small scattered epiphyllous groups of 3-7, often on the mid-rib, seated on discoloured spots. Peridia cylindrical, standing above the leaf surface 1.5 mm., 0.3-0.5 mm. diameter, margins eroded, finally lacerate. Spores shortly obovate, subglobose or polygonal, 24-30 x 16-22 mmm.; epispore hyaline, 1 mmm. thick, covered with densely packed angular warts, appearing reticulate-areolate in consequence.

II. Uredosori scattered, hypophyllous, orange, fading to sulphur-yellow, crowded in the vicinity of the mid-rib, orbicular, 0.5-1.5 mm. diam., pulverulent, naked. Spores fusiform, clavate or seldom elliptical, pointed at one or both ends, 40-56 x 16-20 mmm.; epispore hyaline, smooth, 1.5 mmm. thick, thickened apically to 4 mmm.; germ pores absent, replaced by odd scattered thin places in the wall; mixed with numerous hyaline, cylindrical paraphyses.

III. Teleutosori similar to and mixed with the uredosori, sulphur-yellow. Spores elliptical or clavate, 80-100 x 20-30 mmm.; apex rounded, not or scarcely thickened, basal cell nearly twice as long as the upper, and narrower; constricted at the septum; epispore tinted brown, 1 mmm. thick, smooth; pedicel persistent, hyaline, to 140 x 8 mmm.; germ pore of the upper cell apical, basal pore immediately beneath the septum, both obscure; immixed with numerous hyaline cylindrical paraphyses.

X. Mesospores rare, elliptical or obovate, 30-50 x 18-26 mmm.

Host: *Olearia lacunosa* Hook. f.

Mt. Arthur, Nelson, 1,300 m. 2/28. *G.H.C.* Type.

Mt. Rangitaipo, Westland, 1,200 m. 2/28. *G.H.C.*

Mt. Trovatore, Westland, 1,000 m. 2/28. *G.H.C.*

Mt. Mantell, Westland, 1,000-1,500 m. 2/28. *G.H.C.*

Alecs' Knob, Franz Josef Glacier, Westland, 1,000 m. 2/28. *G.H.C.*

The host is endemic and fairly widely distributed through the South Island, but confined to the Tararuas of the North Island (Cheesem. 1925, p. 922).

This species possesses many peculiar features not present in any other New Zealand species; the uredosori are deeply embedded

in the host tissues, when they appear similar to aecidia, but as the spores are not in chains, nor enclosed within peridia, they cannot be confused with such. The most peculiar feature is that the uredospores are smooth, a character rare indeed for this spore stage in the Uredinales. Another peculiarity is that the uredosori are present in the cycle, the only example in which the complete cycle is known in New Zealand *Olearia* and *Senecio* inhabiting species. The teleutospores germinate immediately on reaching maturity, and arise from the uredosori.

6. **Melampsora novae-zelandiae** n. sp. EUPHORBIACEAE.

O. I. Unknown.

II. Uredosori hypophyllous, seated on discoloured spots, orbicular, 0.5-2 mm. diam., scattered or more regularly arranged in circinnate groups, erumpent, orange, fading to pallid ochraceous, surrounded by the ruptured epidermis. Spores subglobose, 16-20 mmm. diameter; epispore hyaline, 3-3.5 mmm. thick, moderately and finely verruculose; germ pores 6-8, scattered, obscure; immixed with numerous, hyaline, capitate paraphyses, swollen at the apex to 24 mmm.

III. Unknown.

Host: *Euphorbia glauca* Forst. f.

Seal Rock, Brighton, Westland, coast, 2/28. *G.H.C.* Type.

Charleston, Westland, coast, 2/28. *G.H.C.*

Cape Foulwind, Westland, coast, 2/28. *G.H.C.*

The host is indigenous and fairly widely spread from the North Cape southwards; it extends also to Norfolk Island (Cheesem. 1925, p. 542).

Although only uredospores are present on the abundant specimens at hand, the plant is obviously a *Melampsora;* the inflated hyaline paraphyses, and type of spores being typical of this genus. As several species have been recorded as occurring on *Euphorbia* elsewhere, and as it is not possible to refer this to any one of these on account of their general similarity in the uredostage, it has been provisionally described as new, until such time as the teleutospores are collected.

7. **Aecidium westlandicum** n. f. sp. RANUNCULACEAE.

O. Unknown.

I. Aecidia hypophyllous, yellowish, scattered evenly over the leaf surface, occasionally on petioles, not distorting; peridia 0.3-0.5 mm. diam., slightly erumpent, margins only showing above the inflated epidermis, scarcely reflexed, white, toothed; spores shortly elliptical, subglobose, seldom polygonal, 18-22 mmm. diam.; epispore hyaline, 1 mmm. thick, densely and minutely verruculose.

Hosts: *Caltha novae-zelandiae* Hook. f.

Sebastopol Range, Mt. Cook, Canterbury, 1,300 m., 1/28 *G.H.C.* Type.

Craigieburn Range, Canterbury, 1,500 m., 1/28. *H. H. Allan!*

Alecs' Knob, Franz Josef Glacier, Westland, 1,300 m., 1/28. *G.H.C.*

Caltha obtusa Cheesem.

Mt. Rangitaipo, Westland, 1,200 m., 2/28. *G.H.C.*

Both hosts are endemic and fairly widely distributed (Cheesem. 1925, p. 454-455).

The mycelium of this rust is systemic, etiolating the leaves and dwarfing the plant, and on this account rendering it conspicuous. Sometimes the aecidia parallel the mid-rib, forming lines of a few aecidia on either side.

Owing to the imperfect descriptions published elsewhere, and to the absence of specimens, it is not possible to identify this species with any other rust occurring on *Caltha*; the sorus characters separate it from a plant McAlpine (1906) has provisionally named *Aecidium Calthae* Grev. (the aecidial stage of ***Puccinia Calthae*** Link), and its systemic habit is a feature not recorded for other species occurring on the same host genus. In view of these facts it is provisionally named as new until such time as the teleutospores have been collected.

SCROPHULARIACEAE.

8. **Aecidium disciforme** McAlpine, *Rusts of Australia*, p. 194, 1906.

O. Unknown.

I. Aecidia amphigenous, chiefly hypophyllous, distorting and etiolating, systemic, scattered evenly and sparsely over the leaf surface; peridia sunken completely in the host tissues, 0.6-0.8 mm. diam., at first opening by a minute pore, becoming cupulate when old; peridial cells to 35 mmm. long, thin walled (2 mmm.), orbicular, readily separable, striated. Spores shortly elliptical, or subglobose, 18-24 mmm.; epispore hyaline, 2.5 mmm. thick, covered with dense coarse, rounded tubercules, contents reddish-orange.

Hosts: ***Hebe glaucophylla*** (Ckn.) Allan, comb. nov.

Mt. Mantell, Westland, 1,700 m., 2/28. *G.H.C.*

Hebe Traversii (Hook. f.) Ckn. et Allan.

Mt. Percival, Canterbury, 1,000 m., 1/28. *H. H. Allan!*

The systemic mycelium, completely submerged peridia with their thin walled, readily separable cells, are the characters of this species. McAlpine records this on *Veronica gracilis* R. Br. and *V. calycina* R. Br., and also mentions the fact that it causes thickening and distortion of the leaves.

9. **Aecidium Hebe** n. f. sp.

O. Unknown.

I. Aecidia hypophyllous, scattered evenly and sparsely over the leaf surface, lemon-yellow in mass; peridia cylindrical, deeply immersed, standing above the surface 0.2-0.3 mm., toothed, 0.3-0.4 mm. diam., finally disappearing in old specimens; peridial cells rhomboid, thick-walled, 6-8 mmm., sculptured, firmly compacted together. Spores polygonal or subglobose, 18-22 mmm. diam; epispore hyaline, densely and minutely verruculose; contents pallid lemon-yellow.

Hosts: *Hebe Treadwellii* Ckn. et Allan.
Black Birch Creek, Mt. Cook, Canterbury, 1,200 m., 1/28. *G.H.C.* Type.
Hebe macrantha (Hook. f.) Ckn. et Allan.
Sealey Range, Mt. Cook, Canterbury, 1,300 m., 1/28. *H. H. Allan.*
Hebe macrantha var. *brachyphylla* (Cheesem.) Ckn. et Allan.
Mt. Isobel, Canterbury, 900 m., 1/28. *G.H.C.*
Hebe Traversii (Hook. f.) Ckn. et Allan.
Mt. Isobel, Canterbury, 900 m., 1/28. *G.H.C.*
Hebe elliptica (Forst. f.) Pennell.
Seal Rock, Brighton, Westland, coast, 2/28. *G.H.C.*
Charleston, Westland, coast, 2/28. *G.H.C.*

This differs from the preceding in the different nature of the peridium, in not being systemic, and in the much finer markings of the spores. It differs from *Aecidium Veronicae* Berk. a species recorded from Australia, in that the spores are much smaller, and possess thinner epispores.

CAMPANULACEAE.

10. **Aecidium microstomum** Berkeley, *Journ. Linnean Society,* vol. 13, p. 173, 1872.

A. Lobeliae Theum., *Grev.*, vol. 4, p. 75, 1875.

O. Pycnia in small groups, amphigenous, flask-shaped, semi-erumpent.

I. Aecidia amphigenous, crowded on leaves and petioles, etiolating, orange; peridia bullate, elliptical or subglobose, 0.5-2 mm. long, at first covered by the host tissue, and opening by a narrow pore. later becoming bullate and rupturing longitudinally; composed of a few scattered cells without definite cohesion, oval, flattened, to 40 mmm. long, verruculose. Spores subglobose, 22-24 mmm.; epispore hyaline, 2 mmm. thick, finely and densely tuberculate-areolate.

Hosts: *Pratia macrodon* Hook. f.
Kirkliston Range, Otago, 1,200 m., 1/28. *G.H.C.*
Craigieburn Range, Canterbury, 1,800 m., 1/28. *G.H.C.*
Mt. Trovatore, Westland, 1,300 m., 2/28. *G.H.C.*
Pratia angulata (Forst. f.) Hook. f.
Raikaia Gorge, Canterbury, 400 m., 1/28. *G.H.C.*

The latter host is endemic and fairly widely distributed; the former is confined to the South Island (Cheesem. 1925, p. 885).

The mycelium of this species is systemic, tending to etiolate and distort infected plants, rendering them conspicuous on this account. The very imperfect peridium is absent entirely from numerous sori, so that the plant is on the border line between an aecidium and a caeoma. When present the peridium consists of a few scattered dissociated cells, imperfectly cohering, and held in place by the epidermis; consequently this structure is seen as a rule only in young sori, before the epidermis has fissured.

McAlpine (1906, p. 149) has also commented on this fact; he records this stage on *Pratia erecta* Gaudich., *P. pedunculata* Benth., and *P. platycalyx* Benth., as well as on *Lobelia anceps* L., *L. pratioides* Benth., and *L. purpurascens* R. Br. He places the form

under *Puccinia aucta* Berk. et F. v. M., because *Lobelia anceps* is a host for both; he has not succeeded in finding both stages on the same host at the same time, however. I believe them to be distinct because in the numerous collections of the aecidium recorded above and of *Puccinia aucta,* aecidia are confined to *Pratia* spp., teleutospores to *Lobelia anceps.* Further, collections of *Lobelia anceps* taken at all times of the year from a locality near Seatoun, have yielded only teleutospores.

11. **Aecidium Traversiae** n. f. sp. COMPOSITAE.

O. Pycnia hypophyllous, associated with the aecidia, immersed.

I. Aecidia epiphyllous, on laterals and branches; on leaves in small scattered groups up to 5 mm. diam., on laterals and stems forming elliptical areas up to 10 mm. long, pallid yellow; peridia 0.4-0.5 mm. diam., flask-shaped, opening to the exterior by a small aperture, scarcely evident above the surface of the tissues, margins fimbriate. Spores irregular in shape, elliptical, tending to fusiform, clavate or pyriform, sometimes apiculate, 36-43 x 22-28 mmm.; epispore hyaline, 1.5 mmm. thick, densely and finely verruculose.

Host: *Traversia baccharoides* Hook. f.

Mt. Mantell, Westland, 1,700 m., 2/28. *G.H.C.* Type.

The host is endemic and confined to the mountains of the South Island (Cheesem. 1925, p. 1027).

On laterals are sometimes produced distorted inflations, but as a rule the rust is evident only on account of the colour of the aecidia in mass.

12. **Aecidium otira** n. f. sp.

O. Pycnia chiefly epiphyllous, flask-shaped, sparse, scattered, immersed, associated with the aecidia.

I. Aecidia amphigenous and on petioles and stems, in scattered groups of 3-5, seated on discoloured spots visible on both surfaces, pallid orange, becoming lemon yellow; peridia 0.4-0.5 mm. diam., up to 2 mm. above the leaf surface, at first cylindrical, and scarcely revolute, eroded, becoming lacerate with age; cells polyhedral, to 70 mmm. long, hyaline, thick walled, sculptured. Spores elliptical, or obovate, 38-52 x 22-28 mmm.; epispore hyaline, 1.5 mmm. thick, densely covered with angular deciduous warts, appearing reticulate.

Host: *Olearia arborescens* (Forst. f.) Ckn. et Laing.

Mt. Egmont, Taranaki, 1,000 m., 2/23. *E. H. Atkinson!*; 1,300 m., 4/25, *J. C. Neill!*; 11/27, 1,000 m., *G.H.C.*

Arthur's Pass, Canterbury, 900 m., 1/28. *G.H.C.*

Alecs' Knob, Franz Josef Glacier, Westland, 1,300 m., 1/28 *G.H.C.*

The host is endemic and common throughout (Cheesem. 1925, p. 919). The aecidium shows a general resemblance to that of *Puccinia novae-zelandiae* G. H. Cunn. (and was included under this species in a previous paper) in its cylindrical shape, but differs in the hyaline, not tinted epispore, and in this structure being reticulate and not verruculose.

13. Uredo haumata n. f. sp. GRAMINEAE.

II. Uredosori hypophyllous, seated on discoloured spots visible on the upper surface, scattered and elliptical when up to 3 mm. long, or aggregated into linear series 1 cm. or more in length, pulverulent, pallid ferruginous brown, partly covered by the ruptured epidermis. Spores subglobose, or shortly elliptical, 36-42 x 32-36 mmm.; epispore pallid chestnut-brown, 2 mmm. thick, moderately and finely verruculose; germ pores scattered, 7-11, obscure.

Hosts: *Danthonia Cunninghamii* Hook. f.

Base of Stocking Glacier, Mt. Cook, Canterbury, 1,000 m., 1/28. *G.H.C.*

Tasman Moraine, Mt. Cook, Canterbury, 800 m., 1/28. *G.H.C.* Type.

Danthonia flavescens Hook. f.

Little Peel, Canterbury, 1,000 m., 1/28. *G.H.C.*

Both hosts are endemic and widely distributed (Cheesem. 1925, p. 172).

The spores are larger than those described by McAlpine (1906) for *Uromyces Danthoniae* from Australia, but otherwise show a general resemblance, especially in the numerous scattered germ pores. The species shows also a general resemblance to *Uredo toetoe* G. H. Cunn. on *Arundo conspicua,* but is separated by the much larger spores.

14. Uredo Schoenus n. f. sp. CYPERACEAE.

II. Uredosori scattered, seldom confluent, seated on discoloured reddish spots, elliptical, 1-2 mm. long, erumpent, bullate, long covered, ferruginous. Spores elliptical or obovate, 40-48 x 24-28 mmm.; epispore pallid fuscous, or yellowish-brown, 3 mmm. thick, save at the apex where thickened to 6 mmm. and darker in colour, moderately and somewhat coarsely echinulate; germ pores equatorial, 3-4, obscure.

Host: *Schoenus pauciflorus* Hook. f.

Cook Range, Canterbury, 700 m., 1/28. *G.H.C.* Type.

The host is endemic and common throughout (Cheesem. 1925, p. 229).

15. Uredo moschatus n. f. sp. COMPOSITAE.

II. Uredosori hypophyllous, scattered, orbicular, 0.5-1 mm. diam., pulverulent, pallid lemon-yellow, deeply immersed in the tomentum of the leaf. Spores subglobose or obovate, 24-30 x 20-24 mmm.; epispore hyaline, 1 mmm. thick, finely and closely covered with small round-topped deciduous verrucae; germ pores equatorial, 3-4, not definite, appearing usually as thin places in the wall; immixed with numerous cylindrical, hyaline paraphyses.

Host: *Olearia moschata* Hook. f.

Black Birch Creek, Mt. Cook, Canterbury, 1,200 m. 1/28. *G.H.C.* Type.

The host is endemic and confined to the South Island (Cheesem. 1925, p. 923).

The hyaline thin epispore characterizes the species.

16. **Uredo Cheesemanii** n. f. sp.

II. Uredosori crowded in epiphyllous, orbicular groups up to 5 mm. diam., deeply sunken in the tissues so that the apertures alone are visible, 0.5 mm. diam. Spores shortly elliptical, slightly obovate, often angular, 40-56 x 32-44 mmm.; epispore pallid cinnamon-brown, 4-5 mmm. thick, sparsely and irregularly echinulate; germ pores equatorial, 4, obscure.

Host: *Senecio Adamsii* Cheesem.

Mount Arthur Plateau, Nelson, *T. F. Cheeseman.* Type.

The host is endemic and occurs in both Islands; but is confined to the Tararua Range in the North Island. (Cheesem. 1925, p. 1024).

The sori resemble aecidia in that they are submerged within the flask-shaped cavities in the host tissues; the resemblance is further strengthened in that the cavities are in part lined with fungous tissue in the nature of a pseudoparenchyma; but as the spores are not in chains, and as no definite peridial cells are present, the plant must be considered an *Uredo.*

The species is named from material taken from a collection of the host in the Petrie herbarium, collected by the late Mr. T. F. Cheeseman.

Additional Hosts.

Puccinia hectorensis G. H. Cunn. (*T.N.Z.I.*, vol. 54, p. 683, 1923).
Senecio viridis Kirk.
Mt. Mantell, Westland, 1,700 m. 2/28. *G.H.C.*
Senecio elaeagnifolius Hook. f.
Mountain south of Fox Glacier, Westland 1,000 m. 1/28. *G.H.C.*

Puccinia Atkinsonii G. H. Cunn. (*Ibid.*, vol. 54, p. 675, 1923).
Olearia ilicifolia Hook. f.
Franz Josef Glacier, Westland, 250 m. 1/28. *G.H.C.*
Olearia ilicifolia x *lacunosa* (= *O. mollis* (Kirk) Ckn.).
Mt. Rangitaipo, Westland, 1,200 m. 1/93. *D. Petrie!*
Teramakau River, Westland, 150 m. 1/93. *D. Petrie!*

Puccinia pounamu G. H. Cunn. (*Ibid.*, vol. 54, p. 688, 1923).
Senecio bellidioides Hook. f.
Mt. Mantell, Westland, 1,800 m. 2/28. *G.H.C.*

Puccinia whakatipu G. H. Cunn. (*Ibid.*, vol. 55, p. 4, 1924).
Anisotome petraea Cheesem.
Mt. Torlesse, Canterbury, 1,100 m. 1/93. *D. Petrie!*
Takitimu Mts., Southland, 1,200 m. 12/12. *D. Petrie!*
Anisotome imbricata (Hook. f.) Ckn.
Mt. Trovatore, Westland, 1,000 m. 2/28. *G.H.C.*

Puccinia kopoti G. H. Cunn. (*Ibid.*, vol. 54, p. 668, 1923).
Anisotome intermedia Hook. f.
Catlin's River, Otago, *J. T. Bryant!* (ex Petrie Herb.).
Anisotome pilifera (Hook. f.) Ckn. et Laing.
Mt. Trovatore, Westland, 1,500 m. 2/28. *G.H.C.*

Puccinia Celmisiae G. H. Cunn. (*Ibid.*, vol. 55, p. 8, 1924).
Celmisia Armstrongii Petrie.
Arthurs Pass, Canterbury, 700-1,000 m. 1/28. *H. H. Allan-G.H.C.*
Celmisia Lyallii Hook. f.
Sebastopol Range, Mt. Cook, Canterbury, 1,300 m. 1/28. *G.H.C.*
Celmisia Lyallii x *longifolia.*
Sebastopol Range, Canterbury, 1,500 m. 1/28. *G.H.C.*
Celmisia Lyallii x *spectabilis.*
Mt. Torlesse, Canterbury, 1,200 m. 1/28. *G.H.C.*
Celmisia Traversii Hook. f.
Mt. Arthur, Nelson, 1,300 m., 1,930 m. 2/28. *G.H.C.*
Mt. Trovatore, Westland, 1,200 m. 2/28. *G.H.C.*
Celmisia graminifolia Hook. f.
Mt. Trovatore, Westland, 1,700 m. 2/28. *G.H.C.*

Puccinia pulverulenta Grev. (*Ibid.*, vol. 54, p. 665, 1923).
Epilobium Cockaynianum Petrie.
Mt. Holdsworth, Wellington, 1,250 m. 1/08. *D. Petrie!*
Epilobium junceum Spreng.
Hermitage, Mt. Cook, Canterbury, 700 m. 1/28. *H. H. Allan!*

Puccinia Plagianthi McAlp. (*Ibid.*, vol. 54, p. 660, 1923).
Hoheria Lyallii Hook. f.
Mt. Hutt, Canterbury, 1,000 m. 1/28. *G.H.C.*
Broken River, Canterbury, 700 m. 1/28. *H. H. Allan!*
Hoheria glabrata Sprag. et Summ.
Arthurs Pass, Canterbury, 900 m. 1/28. *G.H.C.*
Hoheria angustifolia Raoul.
Banks Peninsula, Canterbury, 150 m. 1/28. *H. H. Allan!*

Puccinia inornata G. H. Cunn. (*Ibid.*, vol. 54, p. 657, 1923).
Cardamine bilobata Kirk.
Castle Hill, Canterbury, 600 m. 1/28. *G.H.C.*

Aecidium Plantaginis-variae McAlp. (*Ibid.*, vol. 55, p. 36, 1924).
Plantago Brownii Rapin.
Sebastopol Range, Mt. Cook, Canterbury, 1,300 m. 1/28. *G.H.C.*

Aecidium Celmisiae-discoloris G. H. Cunn. (*Ibid.*, vol. 55, p. 37, 1924).
Celmisia incana Hook. f.
Mt. Percival, Canterbury, 1,800 m. 1/28. *H. H. Allan!*
Celmisia incana x *discolor.*
Mt. Rangitaipo, Westland, 1,000-1,200 m. 2/28. *G.H.C.*
Celmisia novae-zelandiae (Buch.) Cheesem.
Cook Range, Canterbury, 700 m. 1/28. *G.H.C.*
Sebastopol Range, Canterbury, 1,300-1,700 m. 1/28. *H. H. Allan!*
Kirkliston Range, Otago, 1,200 m. 1/28. *G.H.C.*
Celmisia Walkeri Kirk.
Mt. Rangitaipo, Westland, 1,200 m. 2/28. *G.H.C.*
Alecs' Knob, Franz Josef Glacier, Westland, 1,300 m. 1/28. *G.H.C.*

Celmisia viscosa Hook. f.
Otira River, Westland, 1,350 m. 1/93. *D. Petrie!*
Aecidium Celmisiae-Petriei G. H. Cunn. (*Ibid.*, vol. 55, p. 38, 1924).
Celmisia Haastii Hook. f.
Mt. Rangitaipo, Westland, 1,200. 2/28. *H. H. Allan!*

Alterations and Corrections.

Aecidium Macrodontae G. H. Cunn. (*Ibid.*, vol. 55, p. 38, 1924).

This form species has now been connected with its teleutosporic stage, and becomes in consequence a synonymn of ***Puccinia Atkinsonii*** G. H. Cunn.

Uredo southlandicus G. H. Cunn. (*Ibid.*, vol. 55, p. 44, 1924).

This is a synonym of *Uredo Brownii* Syd. (*Annales Mycologici*, vol. 5, p. 338, 1907). Sydows' name was overlooked when my former papers were prepared; but as their name has priority it must supersede that given.

Aecidium Celmisiae-petiolatae G. H. Cunn. (*Ibid.*, vol. 55, p. 37, 1924).

This has now been found to be the aecidial stage of *Puccinia Celmisiae* G. H. Cunn.

Uredo konini nov. nom.
Coleosporium Fuchsiae Cke., *Grev.*, vol. 14, p. 129, 1886.

In a former paper I followed Cooke in placing this species in *Coleosporium*; but recent critical examination of numerous collections has shown that it is not a *Coleosporium*, but an *Uredo*; for the uredo-spores are not in chains but are borne singly on distinct pedicels; and no other spore stage is known. The species cannot be named *Uredo Fuchsiae,* for this combination is already occupied, being used by Arthur and Holway (Arthur, *Am. Jour. Bot.*, vol. 5, p. 538, 1918) for a species on *Fuchsia splendens* Zucc. from Guatemala. As the sole record of the family Coleosporiaceae occurring in Australasia was based on the assumption that this was a species of *Coleosporium,* it is now necessary to delete this family from the list of those occurring in this botanical region.

Examination of the abundant material listed below, has shown that in addition to the correction noted above, the species is peculiar in that two distinct spore types are present; therefore it is considered necessary to replace the description given (*T.N.Z.I.*, vol. 55, p. 25, 1924) by the following emended one:

Uredosori amphigenous, often seated on small angular yellow spots, orbicular, 0.5-1 mm. diam., orange-yellow, pulverulent, surrounded by the ruptured epidermis. Spores of two types: (i) spores obovate or obovate-elliptical, 30-40 x 22-28 mmm.; epispore hyaline, 1.5-2 mmm., thickened apically to 5 mmm., coarsely and sparsely echinulate, spines more prominent apically; (ii) spores 18-24 x 12-18 mmm.; epispore 1 mmm. thick, except at the apex where thickened to 3 mmm.; germ pores inevident.

Hosts: *Fuchsia excorticata* Linn. f.

Type (i): York Bay, Wellington, 100 m. 4/26. *G.H.C.*
Hutt Valley, Wellington, 9/81. *T. Kirk!* Co-type.
Peel Forest, Canterbury, 500 m. 1/28. *H. H. Allan!*
Franz Josef Glacier, Westland, 250 m. 1/28. *G.H.C.*

Type (ii): Weraroa, Wellington, 30 m. 7/19. *G.H.C.*
York Bay, Wellington, 50 m. 10/20. *E. H. Atkinson!*
Seatoun, Wellington, coast. 3/22. *G.H.C.*
Hamilton, Auckland, 100 m. 5/22. *G.H.C.*

Fuchsia perscandens Ckn. et Allan.

Type (ii): Seal Rock, Brighton, Westland, coast. 2/28. *H. H. Allan!*
Feilding, 50 m. 8/28. *H. H. Allan!*

Both these spore types are similar in sorus characters, markings of the epispore, and shape; differing only in size of the spores and corresponding thickness of the epispore and size of the markings. It might be supposed that two species were involved, but the finding of both types of spore in the same sorus has shown them to be but forms of the same species.

USTILAGINALES.

(1) **Tilletia Anthoxanthi** Blytt. GRAMINEAE.

Forh. Vid.-Selsk. Christ 1896, p 31, 1896.

Sori in ovaries, completely enclosed within the glumes, ovate, up to 3 mm. long, becoming pulverulent. Spores subglobose or globose, 22-30 mmm. diam.; epispore covered with a network of raised reticulations 3 mmm. high, surrounding polygonal depressions 3-5 mmm. wide, chestnut-brown.

Host: *Anthoxanthum odoratum* L.

Waimakariri Gorge Bridge, Canterbury, 400 m. 1/27. *G.H.C.*

Bennetts, Canterbury, 250 m. 1/27. *G.H.C.*

Distribution: Europe; North America; New Zealand.

(2) **Cintractia Schoenus** n. sp. CYPERACEAE.

Sori in occasional ovaries, sometimes in all, at first enclosed within the glumes, becoming naked when black, firm and compact, subglobose, to 2 mm. diam. Spores subglobose, shortly elliptical or often angular, 18-24 x 14-18 mmm.; epispore smooth, dark fuscus-brown, almost black, 3 mmm. thick.

Host: *Schoenus pauciflorus* Hook. f.

Cook Range, Canterbury, 700 m. 1/28. *G.H.C.* Type.

This species was abundant on this host in the locality recorded; but was not noted elsewhere despite the fact that hundreds of plants were examined.

(3) **Tuburcinia novae-zelandiae** n. sp RANUNCULACEAE.

Sori amphigenous and caulicolous, up to 25 mm. diam., black, pulverulent, distorting and etiolating the host. Spore balls to 60 mmm. in length, but very variable in size and shape, ranging from as few as two spores surrounded by 7-8 sterile cells, to balls with 20-30 spores enclosed within a complete envelope of sterile cells. Spores subglobose or elliptical, arranged mostly with their long axes longitudinally, 16-22 x 12-16 mmm.; epispore chestnut-brown, 1.5-2 mmm. thick, smooth; sterile cells subglobose, 8-14 mmm. diam., epispore pallid brown, smooth, 1.5 mmm. thick.

Host: *Ranunculus tenuicaulis* Cheesem.

Mt. Mantell, Westland, 1,800 m. 2/28. *G.H.C.* Type.

The host is an endemic species with a limited distribution in the mountain regions of both Islands (Cheesem. 1925, p. 442).

This smut is characterized in that the spore balls are often large and contain numerous spores; differing in this respect from other species of the genus recorded on *Ranunculus* and related genera.

ADDITIONAL HOST.

Ustilago Avenae Jens. (*T.N.Z.I.*, vol. 55, p. 405, 1924).
Avena fatua L.
Hororata, Canterbury. 1/27. *J. C. Neill!*

LITERATURE CITED.

CHEESEMAN, T. F., 1925. *Manual of the New Zealand Flora*, second ed., 1163, pp., Wellington.

CUNNINGHAM, G. H., 1923. The Uredinales, or Rust Fungi, of New Zealand, I. Pucciniaceae, tribe Puccineae. *Transactions of the New Zealand Institute*, vol. 54, pp. 619-704.

—— 1924 The Uredinales, or Rust Fungi, of New Zealand; supplement to Part I. and Part II. *Ibid.*, vol. 55, pp. 1-58.

———— Second Supplement to the Uredinales of New Zealand. *Ibid.*, vol. 55, pp 392-396.

———— The Ustilaginaceae, or Smuts, of New Zealand, *Ibid.*, vol. 55, pp. 397-433.

MCALPINE, D., 1906. *The Rusts of Australia*, 349 pp., Melbourne.

LIST OF SPECIES RECORDED (SYNONYMS IN ITALICS).

LIST OF HOSTS RECORDED.

The Validity of certain Allied Species of the Moss *Campylopus clavatus* R.Br.

By G. O. K. Sainsbury.

[*Read before the Hawke's Bay Philosophical Institute, 11th May, 1928; received by Editor, 14th May, 1298; issued separately, 23rd November, 1928.*]

Mr. H. N. Dixon, in his able revision of the New Zealand Mosses, has tentatively treated *Campylopus appressifolius* Mitt. and *C. insititius* H. F. & W. as distinct from *C. clavatus* R. Br. (*New Zealand Institute Bulletin* No. 3, Part 3, page 84 et seq.). The last named is the earliest published species of the three, and all belong to the *Trichophylli* section of the genus, i.e., those species in which some of the leaves, and especially the comal ones, end in a hyaline hair-point. *C. insititius* does not appear in Hooker's *Handbook*, but *C. appressifolius* is published there from Mitten's manuscript and is described as characterized by its leaves appressed in the dry state and by its dark-coloured auricular cells. In the *Journal of the Linnean Society* (Botany, 40, page 441) Mr. Dixon records, however, that the type plant of *C. clavatus* in Schwaegrichen's Herbarium is marked by large distinct auricles, and he suggests that the practical absence of them in Schwaegrichen's accompanying sketches has led to this species being wrongly treated as one lacking distinct auricles. There is no doubt whatever that the alar cells of *C. clavatus* are quite as distinct as those of *C. appressifolius,* and the descriptions in the *Handbook* are, to this extent, misleading. The taller habit and appressed sterile shoots are therefore the only differences which, if constant, would entitle the latter moss to specific rank, unless two other distinguishing marks mentioned by Mr. Dixon, i.e., the nerve, wider in *C. clavatus,* and the hair-point, shorter in that species, are sufficient to separate them (*Bulletin* No. 3 supra, page 85). I have collected many specimens of both mosses in widely separated regions of the North Island, and have received material of them from correspondents and herbaria, and as the result of an examination of the plants I have reached the conclusion that the two species are not distinguishable, and that consequently *C. appressifolius* is not entitled to specific rank. Plants with appressed sterile shoots appear in gatherings consisting mainly of the typical clavate form of *C. clavatus*; the *appressifolius* character is often associated with quite a short habit of growth; and so far as the hair-point is concerned I have collected specimens of a pronounced *appressifolius* type which lack this character entirely. The width of the nerve too is very variable, sometimes ranging in a single gathering from two-fifths to over one-half the width of the leaf-base. I have lately had an opportunity of examining several specimens of *Campylopus* from Cheeseman's Herbarium, and the original labelling of the packets indicates the difficulties felt in assigning material to these two species. A note by Cheeseman records his opinion that species referred to *C. clavatus* appear to be near *C. appressifolius,* and that he would have considered

them to belong there but for Carl Mueller's opinion to the contrary. Another packet is noted as identified by Geheeb as *C. appressifolius* but considered by Mueller as belonging to the other species. The fact really is that in all these cases the plants with appressed sterile shoots would if picked out make a typical herbarium specimen of the one species, whilst the residue would make equally good specimens of the other, and there cannot I think be any doubt that *C. appressifolius* is not entitled to anything more than varietal rank at the most. This species is not mentioned by Brotherus in the Musci (Vol. 10, Engler and Prantl's *Pflanzenfamilien,* 2nd Edition), but I am unable to say whether or not the omission is accidental. So far as *C. insititius* is concerned the alleged differences are more important. Certain species of the genus are characterized as to the leaves by a supra-alar region of narrow thin-walled hyaline cells passing obliquely upwards and outwards to the margin. This is a striking feature of *C. introflexus* (Hedw.) Mitt. and is considered to be a distinguishing mark of *C. insititius.* The alar cells too of the latter species are said to be very indistinct. Mr. Dixon deals with these characters in the *Journal of the Linnean Society* (vide supra, page 440), and records that one of the two type specimens of *C. clavatus* in Brown's Herbarium possesses a distinct area of hyaline differentiation, whereas this character is conspicuously lacking in the other, the supra-basal cells of which are comparatively short and more or less incrassate. These two specimens are labelled as being collected one in New Holland and the other in Van Diemen's Land, and Mr. Dixon assigns the one to *C. insititius* and the other to *C. clavatus.* Although such a striking difference in areolation would apear to separate the plants quite definitely, I find in the large quantity of material examined that this hyaline differentiation is nearly always present, in a greater or less degree, in plants of *C. clavatus,* including also those of the *appressifolius* type. It is a very variable character, and when present is usually more clearly indicated in the young leaves of the upper part of the stem. In some plants there is no trace of it at all, and this is evidently the case with the type specimen of *C. clavatus*; in others it may be as strongly defined as in *C. introflexus.* As regards the indistinctness of the alar cells I think that this is correlated to some extent with the degree of hyaline differentiation, and there is no doubt that defined cells of this kind are often practically lacking in plants of the *insititius* type; but here again there is a range of variation disclosed pointing to the conclusion that *C. insititius* is only an extreme form of a polymorphic species. *C. clavatus* is a moss of very wide distribution throughout at any rate the North Island and is extremely common on the ground in open situations, especially on clay banks amongst manuka scrub and in road-cuttings. It ranges from sea level to subalpine heights, and it is therefore not surprising to find amongst its members a high degree of variability due perhaps to epharmonic adaptation. I have communicated the results of this investigation to Mr. Dixon and he has expressed the opinion that the conclusions arrived at are probably correct, but that it might be advisable to retain *C. appressifolius* as a variety.

The Raised Beaches of the North East Coast of the South Island of New Zealand.

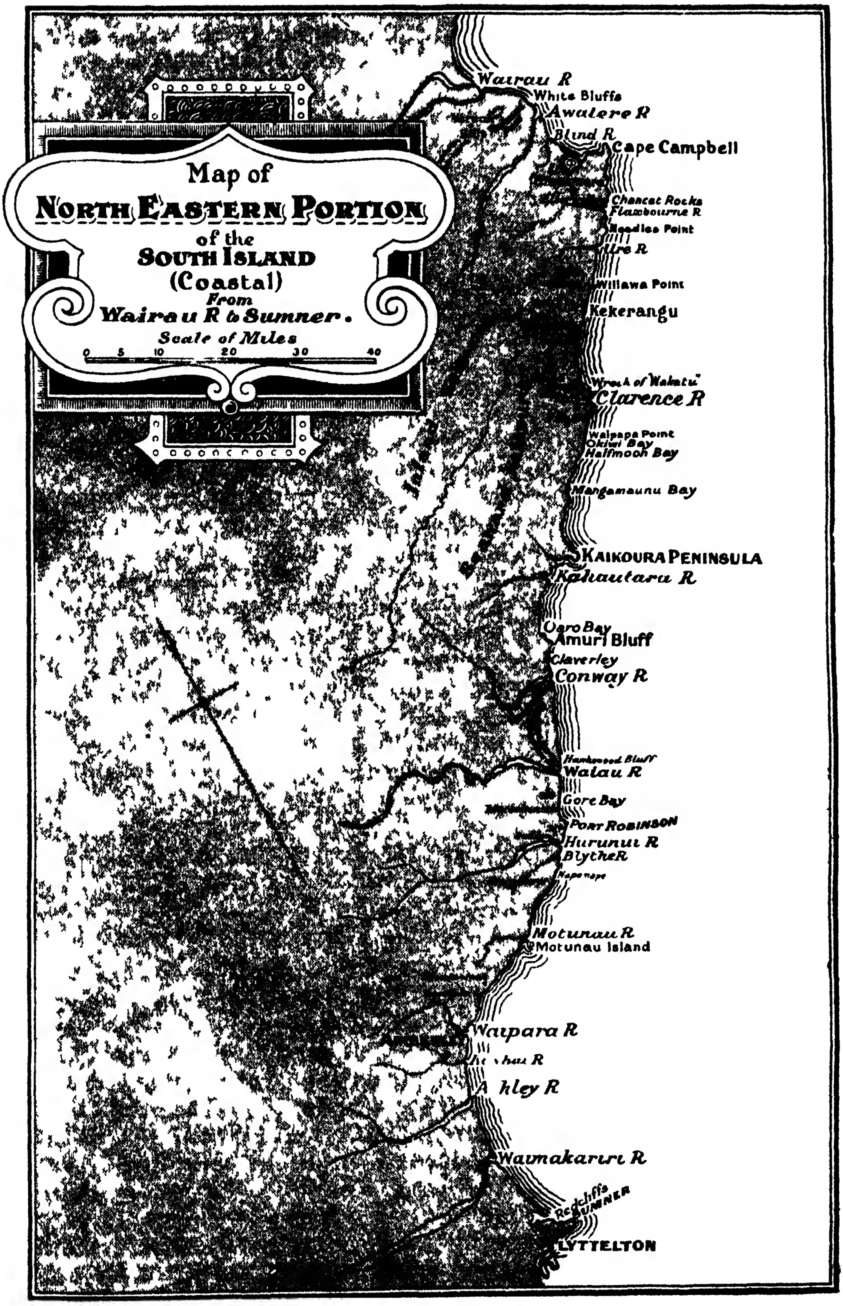
By G. Jobberns, M.A., B.Sc.,
Teachers' Training College, Christchurch, N.Z.

[*Read before the Philosophical Institute of Canterbury, 6th June, 1928, received by Editor, 13th August, 1928; issued separately, 23rd November, 1928.*]

Contents.

Introduction.

This paper embodies the results of an investigation of the evidence indicating changes in the level of the land on that part of the New Zealand coast extending from the Wairau River to Banks Peninsula. Notes on shore-platforms have appeared in the writings of many New Zealand geologists but these have generally been


Map of
NORTH EASTERN PORTION
of the
SOUTH ISLAND
(Coastal)
From
Wairau R to Sumner.
Scale of Miles
0 5 10 20 30 40
Wairau R
White Bluffs
Awatere R
Blind R
Cape Campbell
Chancet Rocks
Flaxbourne R
Needles Point
Willawa Point
Kekerangu
Wreck of Waitatu
Clarence R
Waipapa Point
Okiwi Bay
Halfmoon Bay
Mangamaunu Bay
KAIKOURA PENINSULA
Kahautara R
Oaro Bay
Amuri Bluff
Claverley
Conway R
Hawkswood Bluff
Waiau R
Gore Bay
PORT ROBINSON
Hurunui R
BlytheR
Motunau R
Motunau Island
Waipara R
Waimakariri R
Redcliffs
SUMNER
LYTTELTON

quite subsidiary to other work being done at the time. As an inevitable result the published observations of many of the earlier writers contain widely divergent estimates of the amount of uplift (or subsidence) indicated by coastal features in the same locality, and any attempt made at correlation of these is unsatisfactory, and comes little nearer to solution of the problems presented or to correct interpretation of the evidence of change of position of the shore-line. While the present writer has made the fullest use of the published observations of geologists who have previously visited this part of the coast, notably that of McKay, Hutton, Haast, Park, Cotton, Thomson, and Speight, each section of the coastline described has been examined in some detail, and as far as was considered necessary for correct interpretation of the features of the present shore the geological structure of the adjacent land has also been investigated. During the course of this work the many gravel deposits encountered in the coastal areas were also examined, but in order to avoid undue length of this paper, discussion of these will be reserved.

Work in such an extended field has involved considerable expense, which has been largely borne by a grant from the New Zealand Institute for which the writer's thanks are gratefully recorded. The writer also takes this opportunity of expressing his thanks to many friends and college students who have accompanied him on field-expeditions and to others who have placed at his disposal facilities for carrying out the field-work. To Messrs. G. Gunn, of Seddon, A. Thomson, of Flaxbourne, Montague Wiffen, of Kekerangu, and E. Stocker, of Conway Hills, his thanks in this latter respect are more especially due. The writer also gladly avails himself of this opportunity of expressing his gratitude to Professor R. Speight for his kindly interest in the work, and his assistance on many occasions during its progress.

Part 1.—General Description of the Coast.

A. The Wairau Plain.

The low swampy plains extending inland from the mouth of the Wairau are in marked contrast to the elevated terraces terminating at the coast-line in bold cliffs (up to 350 ft.) in the valley of the lower Awatere. The parallel lower portions of these valleys are separated from each other by the immensely thick gravel-beds of the Vernon Hills, while to the immediate north of the Wairau Plain lies the "downthrown area" of the Marlborough Sounds. The origin of the Wairau Plain has been discussed by Cotton (1913A, pp. 316-22) who describes the northern boundary as an old shore-line running north-eastward from the Tuamarina Valley to the sea—a line of facetted spur-ends which might have been produced by (1) recent faulting, (2) lateral cutting by the Wairau River, or (3) marine erosion. In the south, too, the spurs running out from the main ridge of the Vernon Hills to the Plain are all similarly truncated, ending in fresh-looking steep triangular faces. If this resulted from recent faulting, the fault-junction between the hills and the plain

is now completely masked by more recent fan-deposits of lateral streams. The wide sweeping curves of the cliffed spur-ends suggest that either the Wairau River once flowed round the base of the Vernon Hills to enter the sea near the Big Lagoon or that, which seems more likely, a wide arm of the sea occupied the lower valley. Conditions then were no doubt similar to those obtaining simultaneously at Lake Grassmere a few miles to the south. Wild (1915, p. 414) points out that the Wairau River has apparently carried no gravel nearer to the sea than the present railway-bridge several miles from the shore-line, and that the material of the boulder-bank came as along-shore drift from the south. In all probability the formation of gravel-spits enclosing lagoons both at Lake Grassmere and Cloudy Bay attended the very recent initiation of a cycle of progradation on this part of the Marlborough coast.

Though Henderson (1924, p. 585) suggests that the site of Blenheim has been slightly uplifted, and McKay states that an elevation of 25-30 ft. caused the separation of the neighbouring Queen Charlotte and Pelorus Sounds, there is positive evidence that the most recent movement of the Wairau Delta area has been one of depression (Lyell, 1868, p. 87; Suess, 1906, vol. 2, p. 28; Buick, 1900, p. 332). The writer has not examined the northern edge of the Wairau Plain nor the adjacent Sounds area, but accepts the explanation offered by Wild (*loc. cit.*) and noted by Cotton (1913A, p. 321), that the plain was formed by infilling of an enclosed lagoon with deltaic deposits advancing seawards, and the further raising of the surface by successive floods. In this manner the land could quite well have been built out seawards in spite of an intermittent subsidence of the whole area. However, the question as to whether the Sounds area has actually been submerged far below its present level, and since been partially resurrected by the general uplift so profoundly affecting the remainder of the coast does not seem to have been explored, and this is beyond the scope of the present paper. Cotton (1913A, p. 318) has estimated the extent of submergence of the Sounds area at from 250 ft. to 500 ft., but this does not necessarily afford any indication of the amount of sinking of the Wairau Plain, which appears to have been determined by trough-faulting with infilling of the resulting depression in the manner described above.

The nature of the junction between the plain and the Sounds area to the north and the Vernon Hills to the south remains obscure. Morgan (1916, p. 19) remarks on the remnants of a relatively modern beach only a few feet above high-water mark, especially well developed between Lake Grassmere and Cape Campbell. In January, 1926, the present writer noted these remnants at many points around the White Bluffs. As they were observed in January, 1927, to have been to a large extent removed by heavy seas during the intervening twelve months, they may not afford thoroughly reliable evidence of recent slight elevation of the land. If, as Morgan believed, they indicate a very recent uplift, their immediate proximity to the sunken area of the Wairau Plain suggests that the limit of the sinking block is very sharply defined indeed by the northern base of the Vernon Range.

B. THE VERNON RANGE TO LAKE GRASSMERE.

1. *The Vernon Range*: From the northern base of this range to the point where the Limestone Range reaches the sea about a mile to the east of Lake Grassmere, the coastal area to be described in this section consists entirely of younger Tertiary rocks. These are the stratified gravels of the Vernon Hills and the friable sandy mudstones or marls (the Awatere beds of McKay) which extend for some miles up the Awatere Valley, occupy nearly all the basin of the Blind River, completely encircle Lake Grassmere, and extend across the middle valley of the Flaxbourne River almost to the basin of the Ure.

From Taylor Pass to the sea the Vernon Hills are composed wholly of gravels which can also be traced for many miles farther up the southern side of the Wairau Valley. The hills form a more or less flat-topped dissected ridge rising gently inland from a height of nearly 900 ft. at the White Bluffs where they are truncated by the sea in magnificent cliffs. Some 2½ miles in width, they rise abruptly in sub-maturely graded cliffs from the lower valleys of the Wairau and Awatere rivers between which they form an effective barrier. Although dissection has produced a system of lower rounded spurs running out from the main ridge, the summit of the hills presents a remarkably even sky-line (Cotton, 1914A, Fig. 3, p. 288), and it seems very probable that parallel faulting determining the direction of the major valleys on either side has been to some extent responsible for their isolation in their present position.

The extent of the component gravels is so prodigious as to have caused some speculation as to their mode of origin. Park (1911, p. 522) describes them briefly as "a great pile of fluviatile drifts over 1,200 ft. thick," with a basal layer of glacial debris. He states further, "In places they rest on the older Pliocene clays of the Awatere series," and again, "That they are Pleistocene seems almost certain." McKay, too (1886, p. 123; 1890A, p. 168), considers them to be of a younger age than his "Great Post Miocene Conglomerate." The writer examined sections in the Redwood Pass, in railway-cuttings in the Dashwood Pass, in some of the valleys between the Redwood Pass road and the sea, as well as in the high cliffs at White Bluffs. This latter coast-section shows the gravels to vary considerably in nature from brown loosely-cemented conglomerates where the shore-line has retreated somewhat from the base of the cliffs in the north, to fresh-looking grey sandy shingle in the rapidly-receding cliffs a little farther south. About half way round the bluff, the grey sandy, well-stratified type passes up into highly ferruginous brown beds, the change from one type to the other being in places very gradual. Here the cliffs are marked by lines of fault generally of small displacement. No beds other than these stratified gravels with a uniformly low south-easterly dip are seen in the cliffs until the northern border of the Awatere Valley is reached. Here the cliffs are lower and graded somewhat and the section is obscured, but there is a very abrupt change to the characteristic sandy marls (Awatere beds) in a zone of considerable disturbance due to faulting.

Examination of remarkable sections exposed in narrow defiles debouching at the shore near the Wairau Plain, shows considerable

variety in texture of the gravels from well-stratified sandy beds to coarse banded conglomerates with large rounded and sub-angular boulders and interstratified lenses of sandy mudstone. These defiles, with vertical or overhanging walls are often of great depth and are extremely narrow, indicating their rapid erosion consequent on recent uplift. The sub-angular nature of the gravels and the medium to fine texture of the greater part of them, though boulders up to 2 ft. in diameter are by no means uncommon, suggest that they are fluviatile or fluvio-marine deposits transported with considerable velocity. There is, however, no evidence except, perhaps, the immense size of the deposits to indicate the fluvio-glacial origin suggested by Park (*loc. cit.*, p. 522).

That the Vernon Range has recently been uplifted some 1,000 ft. to 1,200 ft. cannot be doubted, but marine erosion has caused such rapid recession of the cliffs as to remove almost completely any traces of pauses in the process of emergence. The only remnants of terraces which may reasonably be assumed to be of marine origin are found in the extreme north-eastern area. These stand at 300 to 350 ft. and at 525 ft. However, a better record of stages in the recent elevation is preserved in the immediately adjacent valley of the Awatere River.

2. *The Lower Awatere Valley*: For the purpose of the present paper this area has been adequately discussed by Cotton (1914, pp. 288-89). River-terraces are remarkably well developed, nearly horizontal caps of alluvial gravel being deposited unconformably on the planed edges of the Awatere marls which comprise the basement-rock of the whole coastal area. Everywhere the terraces end abruptly at the shore-line in bold cliffs, which, in the neighbourhood of the Blind River, attain a height of 350 ft., although the surface-cover of recent gravels is discontinuous here. The amount of elevation observed by Cotton agrees very well with the evidence obtained from other parts of this coast, and uplift with pauses at 120 ft., 350 ft., 550 ft. (?), and 800 ft., inferred by him from the present position of river-terrace remnants may be correlated closely with remnants of shore-platforms in neighbouring localities. Here the coast has suffered severe retrogression leaving a somewhat prominent salient where the Awatere River now enters the sea.

3. *Lake Grassmere*: Cut off from the sea by a spit of fine sandy gravel reaching a height of 15 ft. and made up of two distinct barrier beaches, this is now a circular sheet of water nowhere more than 2 to 3 ft. in depth and sometimes quite dry. Cliffs of mudstone, fresh looking and steep on the southerly side and graded and grass-covered in the north extend right round the margin of the lake-basin. The obviously recent marine origin of these cliffs and the rapid rate at which the lake has been known to have silted up since the advent of agriculture, suggest that the sea has abandoned a wide bay very late in Quaternary time. When the land was 120 ft. lower than now, the sea extended to the middle valley of the Flaxbourne River near Ward, and a little earlier with the general level depressed some 350 ft., it no doubt reached almost to the Ure. A long narrow depression lying behind the sharply faulted block of the coastal Limestone Range and widening considerably at the site of the present

lake, was then occupied by the sea, and the formation of the spit accompanying very recent general progradation of the coast, with subsequent rapid infilling of the remnant, merely represents the final stage in the natural reclamation of a very considerable area. Cotton (1914, p. 293, footnote) has observed evidence of strong tilting or warping of the surface to the south-east of Lake Grassmere, and he suggests that it is probably in sympathy with or forms one boundary of a kind of cauldron-like subsidence forming a bay from which the present lake developed. It is apparent, however, that both Lake Grassmere and Lake Elterwater are remnants of the same arm of the sea, and the tilting or warping noted by Cotton may perhaps be attributed to movement connected with the Limestone Range fault-zone, more or less contemporaneously with the general elevation which rejuvenated the streams concerned.

Lake Grassmere to the Needles Point: The topography of this area is dominated by a narrow, sometimes razor-backed ridge of limestone extending from a point about a mile to the east of Lake Grassmere to the mouth of the Flaxbourne River. Near Lake Grassmere the rocks that form it strike N. 50° E. dipping S.-easterly at an angle increasing from 50° to 75° in an extensive wave-levelled reef. Here the limestone is thinly banded with interleaved layers of greensand, and is much disturbed by the great fault which has determined its landward margin, and which has so completely crushed the stone at Flaxbourne (Morgan, 1916A, p. 19; 1916B, p. 15; 1919, p. 199). It appears on the coast again at the Chancet Rocks where it shows extraordinary disturbance of dip and strike, passes across the lower Flaxbourne Valley to Weld Cone, the Needles Point, and a reef opposite the mouth of Mirza Creek where, steeply tilted seawards, it has regained its normal strike almost parallel to the coast. It is probably the same band of limestone which appears again at intervals at the shore-line, notably at Willawa Point and Deadmans Creek, at both of which places it dips steeply to the north-west. From Lake Grassmere to the Chancet Rocks the general dip of the beds is south-easterly. Then follows a zone of acute distortion and faulting extending from the Chancet Rocks to the neighbourhood of the Ure River, to the south of which the dip changes abruptly to the north-west. This general direction of dip is preserved throughout an area somewhat dislocated by faulting, until the south bank of the lower Clarence Valley is reached where the beds are folded into a syncline sharply bounded inland by a fault.

This section of the paper, however, is concerned only with a description of the area on the seaward side of the Limestone Range referred to above. In McKay's description of the locality (1877, map and sections, p. 188), he refers to the enormous thickness of grey marls (8,000 ft.) developed here. Morgan (1916A, p. 18) doubted the accuracy of this estimate, suggesting that the existence of a fault in the section might necessitate its revision. The writer examined the coast-line section from the limestone reef near Lake Grassmere to the lighthouse at Cape Campbell—i.e., McKay's section (AA map, p. 188) at right angles to the general strike of the beds. It is very difficult to observe the direction of dip of such marls as are exposed in the cliffs. Near the limestone reef they stand almost

vertically and show sharp contortion over some distance, but near Fisherman Creek the dip has flattened somewhat, becoming flatter still near Mt. Tako. Just past this point hard bands exposed in the shore-platform at low tide indicate a reversal of dip to the north-west, though stratification is not shown in the cliffs. At the cape the dip is seen to be south-easterly again at about 40°. Whether the reversal of dip is due to the faulting suggested by Morgan or to simple folding is not clear but in any case McKay's estimate of 8,000 ft. probably very much exceeds the actual thickness of the beds. The marls are, however, developed over a wide area and also form extensive reefs off shore for several miles down the coast.

Rock Platforms: In the neighbourhood of Cape Campbell large areas of well-planed surfaces cut in the soft grey marl are exposed at low tide both on the east and west sides of the promontory, while a reef extends off-shore from the cape itself for nearly half a mile. On the east side, where the strike of the beds is parallel to the shoreline, flat wave-cut surfaces can be traced along the coast for several miles, while harder fragments of reefs project above the sea upwards of a mile from the shore. On the west side, i.e., between Cape Campbell and Fisherman Creek, the marl cliffs are receding rapidly. The marl is generally uniformly soft throughout, giving a very even surface to the cut platforms, but some two miles south of the cape occasional hard bands stand out like walls 6 to 8 ft. above the general level. The inner edge of the platform at the cape is loaded with drift-material piled up in two distinct terraces rising about 11 ft. above high-water mark, but this may not necessarily be due to recent uplift when the neighbouring cliffs near Mt. Tako are being attacked so vigorously by the sea. With excessive alongshore drift of waste, the large protruding reef at Cape Campbell would act as a breakwater, causing the loading of the platform. The very great seaward extension of the cut platform exposed at low tide suggests, too, that its inner edge is actually not above high-water mark.

Raised Shore Platforms: A general view of this area from any point on the summit of the Limestone Range suggests some former uniformity of surface-level in a land now sub-maturely dissected by streams, notably Fisherman Creek following a north-easterly course along the base of the Range, and others such as the Boo Boo Stream and Canterbury Gully following a course to the south-east. The only notably high land is Mt. Tako (642 ft.), a flat topped mass in the extreme north-east. Similar flat surfaces up to 471 ft. occur just north of the Boo Boo Stream, but by far the greater part of the area is not higher than 350 ft. The only definite remnants of recent marine deposits found by the writer occur at Long Point, where the steeply-tilted marl beds are capped unconformably by thick beds of marine pebbly gravels and sands up to a height of 160 ft. These are probably the deposits referred to by Morgan (1916A, p. 19), though McKay (1886, p. 125) says, "They (high-level gravels) are absent along the whole coast line from Cape Campbell to Kekerangu."

Both Morgan (1916A, p. 19) and Cotton (1914A, p. 286) refer to a remnant of a shore-platform at Cape Campbell, the former stating, " The projection forming Cape Campbell is flat-topped, and

is clearly a fragment of a sea-worn terrace formed when the land was roughly 200 ft. below its present level." While the general level of the much dissected land immediately behind the projection of the cape itself is fairly uniform at 330 ft. to 350 ft. the projecting portion is simply a razor-backed ridge, a remnant which has survived the attack of the sea on both sides only by the recent accumulation of protective drift-material at its base. It is by no means certain or likely that it represents a fragment of a wave-cut platform at 200 ft. Much more convincing evidence of an elevation of 150 ft. or so is afforded by the rejuvenation of stream-valleys and deposits of gravel on the summit of marine cliffs in the immediate neighbourhood of Lake Grassmere. Here, too, are flat-topped spurs rising to 250 ft. near the point where the Limestone Range is truncated by the sea. These may possibly indicate a period of standstill at that level.

The writer took advantage of an opportunity to examine the country in the neighbourhood of Mr. A. Thomson's "Chancet" homestead. Here the Limestone Range attains its maximum height of some 1,100 ft., while on its steep seaward face is a very pronounced and continuous ledge at 800 ft. Whether this may be regarded as a remnant of a cut platform is by no means certain, but its height can be correlated with undoubted evidence from the Awatere Valley recorded by Cotton.

Residuals of Rock Platforms at Flaxbourne: Cotton infers uplift of some 6 ft. from flat topped remnants of a dissected shore-platform in this locality (1914A, p. 293). These seem to be restricted to a small part of the shore-line between the Needles Point and the Chancet Rocks, at both of which points slight elevation may also be inferred from the isolation of rock-stacks. Immediately to the north of the Chancet reef the strand-plain is built of blocks of broken limestone and crushed debris from the steeply-tilted faulted ridge, while the limestone in the reef stands in an almost vertical attitude and strikes N.N.W.-S.S.E. running out to sea in a line of stacks showing most remarkable contortion of the component rock. Then just below the mouth of the Flaxbourne River the limestone strikes N. 26° E., almost parallel to the coast, and dips easterly at 70°. Between Weld Cone and the Needles Point all the rocks are involved in a zone of faulting, and show excessive contortion, and shattering with complete reversal of dip and strike within a radius of a few yards. This remarkable disturbance occurs within a limited area to which the residuals noted by Cotton are restricted. Therefore while elevation of 6 ft. to 8 ft. or perhaps a little more has without doubt occurred here quite recently, the present writer would hesitate to say that it is necessarily a general feature of adjacent parts of the coast, notwithstanding the fact that a narrow rapidly-prograding strand-plain seems almost continuous for a considerable distance.

D. THE NEEDLES POINT TO WAIPAPA POINT.

From the Needles Point to the Ure River the recent strand-plain shows a rapid increase in width, but there is no good record preserved of pauses in the process of emergence. Here are extensive dunes of wind-blown sand, passing southward into large fans of loose shingle deposited by the Ure and the streams to the south of

it. The fan of the Woodside Creek rises from sea level to 50 ft. at the Main North Road, in a distance somewhat less than a mile, and the stream-bed is filled with boulders of large size. These alluvial fans play an important part in the prograding process from this point to the Clarence—i.e., in that part of the Marlborough coast where the recent strand-plain reaches its maximum development. Single Hill (503 ft.) indicates the average height of the coastal country, while just below the Woodside Creek bridge there is a very flat ledge at approximately the same height cut in limestone, but capped only with loose sharply-angular chips of limestone showing no sign of marine origin.

River-terraces in the lower Kekerangu area have been described by Cotton (1914A, p. 290; 1918, p. 146), his estimate of a recent elevation of 120 ft. being a conservative one. A general examination of the country indicates that this represents a more recent stage in an elevation amounting to at least 500 ft., which corresponds very closely to that so clearly indicated by terraces in the lower Clarence Valley a little to the south.

The component rocks in the lower Kekerangu area are marls traversed by faults along the line of which at least two of the three parallel bands of "The Great Marlborough Conglomerate" are involved. The greatest of these faults is that which is clearly seen in the limestone in the lower Benmore Stream near its junction with the Kekerangu, and which crosses Heaver Creek where the middle line of conglomerate is involved (McKay, 1890A, p. 173). Evidence of quite recent displacement may be seen at the surface here. Where least disturbed the rocks in this area stand almost vertically or dip north-westerly at fairly high angles. Grey sandy marls are the predominant rocks, and these have offered little resistance to erosion; the surface is therefore of a broadly undulating, sub-maturely dissected type. Near the Napoleon Station Homestead, however, there are two, perhaps three, intrusive sills of basalt, defining the tops of the ridges behind the house. McKay (1886, p. 87) refers to these as interbedded sheets, but the induration of the under-surface of the overlying beds suggests their intrusive nature. These ridges of harder rock are nowhere much in excess of 500 ft. in height, and this may reasonably be supposed to represent the height of a formerly regular surface. There is a noticeable regular increase in height to the north-east near Shaw Fall or the "White Slip," where, owing to the steep angle of inclination of the beds and their broken nature, they slip seawards in great masses to be cliffed by the sea at a point where the usual narrow strand-plain disappears from the coast. Reference has been made by various writers to this part of the coast, more especially in connection with discussion of the Great Marlborough Conglomerate, but this is beyond the scope of the present paper. It is these gravel-beds which form the steep homoclinal ridge of Deadman Hill and the reefs near the mouth of the Kekerangu River. They appear to overlie the marly beds which extend through the coastal cliffs from here to the neighbourhood of the north bank of the lower Clarence Valley.

The only deposits of importance to the present discussion are the thick beds of recent gravels and sands lying unconformably on the

planed edges of the marls in the vicinity of the Ngaio Downs Station. It is in the southern portion of this locality particularly that the recent gravel-cap is remarkable for its great thickness, and for a slight landward tilt suggestive of warping. Near Pigeon Hill the following sequence is seen in the upper beds (in ascending order):—

a. Basal gravels, loose well-rounded pebbles of moderate size.
b. Fine sands, well stratified with abundant interstratified bands of pebbles.
c. Coarse rounded boulders in a matrix of fine sand. These beds together have a thickness of nearly 100 ft., and are capped by,
d. Fine sandy clay. 20-30 ft.

These beds are separated from the high-level terrace gravels of the lower Clarence Valley by a high undulating ridge in which Pigeon Hill (966 ft.) is prominent, and from their position they are most probably of marine origin. There appear to be two sets of terraces, one at 300-350 ft., the other at 500-550 ft., but they are of a very fragmentary nature. Between Pigeon Hill and Otu-Kaku Point the marls of the cliffs give place to the thick gravel-beds of the so-called Clarence Delta, to appear again in the end of the razor-backed ridge opposite the wrecks of the "Taiaroa" and the "Wakatu."

The high level terraces of the lower Clarence: The structure of the so-called Clarence Delta was examined in some detail, but correct interpretation of the facts observed is hampered by the writer's lack of knowledge of the geology of the country between Corner Hill and the Kekerangu Valley across the upper Ericaburn.

a. *North Bank*: A section through the northern part of the "Delta" from Otu-Kaku Point to Corner Hill, a distance of three miles, shows the following in ascending order:—

1. Marls, grey, stiff, very argillaceous. Exposed on the extreme seaward end of the "Delta" for a few chains. Strike N. 27° E. Dip north-westerly, 33°.

2. Gravels. The lowest beds exposed are fairly fine gravels with interstratified bands of soft friable sandstone. The contact between the gravels and the underlying marls cannot be seen, but as far as can be judged from dip and strike they overlie the marls conformably. The dip of the gravel-beds which are nowhere seen to be very coarse in texture, but which may be cemented to form a hard conglomerate, continues north-westerly for over 2½ miles. No satisfactory exposures are to be obtained near the Woodbank Homestead, but the writer found no indication whatever of reversal of dip throughout the section.

3. Dark reddish sandstone reduced to a fine sand at a zone of crushing at Corner Hill. A small wedge-shaped mass of this sandstone is involved in a powerful reversed fault, which has also caused considerable crushing of the immediately-adjacent gravel-beds.

4. Reversed fault, running N. and S. (mag.). The plane inclines to the west at 50°.

5. Amuri limestone, forms a steep bluff against the base of which the main stream of the Clarence River impinges. The lime-

stone stands in an almost vertical position, but is much contorted, and the surface involved in the fault is perfectly slickensided.

This section was not seen by McKay, but he notes that Hector examined a section on the east bank of the Clarence in December, 1873, and described the conglomerates as being folded in anticlines and synclines on the north-west side of the Amuri limestone (McKay, 1890A, p. 173). As remarked above, exposures are not good in the high terrace bank in the vicinity of Woodbank, but wherever seen the beds dip persistently to the north-west. The present writer did not investigate the structure in the area to the north-west of Corner Hill examined by Hector, and it is not proposed to discuss in this paper the stratigraphical position of the gravel-beds, but it may be remarked that the chief difficulties in the interpretation of the section lie in determination of the age of the grey marls exposed at Otu-Kaku Point, and in explanation of the occurrence of the brecciated older rocks at the Corner Hill fault-junction.

Unfortunately the only description of this part of the coast is to be found in Cotton's purely physiographical writings (1914A, pp. 286-294; 1916A, pp. 20-47; 1922, pp. 204-208). He attributes the mode of deposition of the gravels to foresetting as shown in typical delta-structure, but on the north bank the gravel beds dip persistently landwards. The only point where the nature or structure of the component gravels has been described at all is in the south bank of the river near the Clarence Bridge—i.e., "The foreset portion of the delta, which, however does not show stratification." (1914A, p. 292). At this point, however, the apparently unstratified gravels form the core of the syncline into which all the beds on the south bank are folded. The upturned edges of the beds in this syncline were then planed off and the thick beds of a recent surface-cap deposited on them. If the gravels were ever deposited as a delta, it was at a very much earlier date than that suggested by Cotton's description, and they do not now exhibit in the slightest degree the structure typical of the foreset beds of a delta.

b. *The South Bank*: The contact between the conglomerate beds and the limestone forming the steep ridges behind them could not be seen at any point near the road past the Waipapa Homestead, nor is it exposed in the valley of the Porangahau Stream a little to the south. There can be little doubt, however, that the great reversed fault described above crosses the Clarence River to reach the sea at Waipapa Point where the excessive disturbance of the strata has been described by McKay (1886, p. 84). Where first seen on the Waipapa road near the limestone, the gravels are exposed in steep cliffs by the roadside. Here they are not very distinctly stratified, but appear to stand almost vertically. Traced downstream towards the bridge, they are seen to dip easterly at a steep angle, flattening noticeably as the Waipapa Homestead is passed.

In a bare sandy ridge where the Main North Road crosses Garret Stream (the first south of the Clarence), the older gravels are seen to dip inland (north-westerly) at 40°, the strike being N. 26° E. Here the younger surface beds lying across the upturned edges of the conglomerates, consist of remarkably uniform material, being on the whole fine-grained with coarser and finer bands alternat-

ing with great regularity. The whole series is well oxidized to a deep brown and capped with about 20 ft. of loess-like clay. The sandstone involved in the Corner Hill fault and exposed on the hillside just above it could not be found in position on the southern side of the river, but an elevated flat surface at 350 ft. above Edgecombe, is covered with huge angular blocks of a similar rock indicating its close proxmity to this point.

As far as can be seen, therefore, the southern portion of the "delta" consists of gravel-beds, generally well cemented to form a hard conglomerate, and is separated from the inland limestone ridge by a fault. The existence of sandstone near the fault can be reasonably inferred, but there is no indication of marl-beds corresponding to those exposed at Otu-Kaku Point, these having been removed by marine erosion, and the platform cut in them being no doubt buried beneath the accumulated shingle and blown sand which forms a low dune-covered strand-plain upwards of a mile in width. To the south of the river all the beds are involved in the syncline, and Hector's record (*loc. cit.*) of similar folding of the gravels to the north-west of Corner Hill, indicates that the extent of the gravel deposits is enormously greater than that indicated in Cotton's map (1914A, p. 290; 1916A, p. 36; 1922, p. 206).

c. *Evidence of Uplift*: McKay seemed to be somewhat uncertain as to the distribution of the gravels of the lower Clarence Valley, but he stated definitely his opinion that the first low terrace north-east of the valley is a raised beach (1886, p. 126; 1890A, p. 182). Cotton inferred elevation amounting to 500 ft. (1914A, p. 291; 1916A, p. 39). From the evidence of valleys dissecting his ancient uplifted delta, he also inferred a pause in the uplift process at about 300 ft. (1914, p. 292). Reasons will be advanced later for regarding Cotton's claim (1916) that the East Marlborough Coast is a "mature resurrected fault coast with a projecting delta built by a large river —the Clarence" as a pure hypothesis, but his estimate of the amount of recent elevation is a quite conservative one.

The lower projection on the north bank of the Clarence terminating in Otu-Kaku Point—i e., the eastern extremity of Cotton's raised delta—is simply a razor-backed ridge from which the surface-cover of horizontal beds has been removed, and which has survived complete destruction by the combined attack of the sea on one hand and the river on the other, only by the very recent initiation of a cycle of progradation following one of rapid cliff-recession. In this respect it is almost precisely similar to the promontory at Cape Campbell.

At Corner Hill the summit of which stands at 777 ft., capped with terrace gravel and angular blocks of limestone (though the limestone outcrop is now denuded much below this), the height of the present river channel is about 130 ft. So there is evidence here of elevation amounting to some 650 ft. The gravel-beds are seen to have an enormous development, lying under and around Corner Hill, preserved so long only by the now very thin buttress of limestone against which the main river impinges, and extending out to the coastal cliffs through Pigeon Hill (966 ft.). The river once flowed just to the north of Corner Hill, where it has left a

terrace deeply dissected now by the Rika, May, and Donkey Streams. From this point it can be seen that Pigeon Hill itself has been terraced at an accordant level, which can be traced to the surface of the flat-topped promontory shown in Cotton's sketches (1914, p. 291, etc.). This promontory is a remnant of a high-level river-terrace which must formerly have extended far to the seaward, and Cotton is mistaken in supposing that its surface slopes away from the river (1914, p. 291).

The combined evidence of river-terraces and remnants of raised beaches in the lower Clarence-Kekerangu area indicates a recent elevation amounting to at least 650 ft., with pauses at 500-550 ft., 350 ft., and 120-150 ft. The writer has no doubt that a similar examination of the area immediately to the north of the lower Clarence Valley would reveal evidence of stages at 800-850 ft. and probably somewhat yet higher.

E. WAIPAPA POINT TO MAUNGAMAUMU BAY.

It is immediately below Waipapa Point, near the mouth of the Mororimu Stream that the limestone of the lower Clarence area makes its last appearance on this part of the coast. From the adjacent Okiwi Bay to the point where the gravels of the recent Hapuku fan reach the shore, the coastal rocks are entirely sandstones. McKay referred these older rocks to his Bastion Formation —i.e., he considered them to be equivalent in age to the Jurassic sandstones of the Amuri Bluff section—and his coloured map (1890, p. 96) shows a strip of the Notocene beds extending from the lower Clarence Valley through the fault-valley of the Puhipuhi to the Hapuku. The mass of older rocks thus isolated on the coast rises to 3,820 ft. in Patutu Peak, and there is every reason to believe that the remarkably regular alternation of rocks of the older and younger series is a characteristic structural feature of the coast, at least from this point southwards. In this locality, however, the relationship of the rocks of the "undermass" to the overlying Notocene beds, and the normal sequence of these beds themselves, has been highly disturbed by faulting. It seems fairly certain that erosion has not proceeded much farther than the complete removal of the Notocene cover from the summit and seaward face of the older projecting mass, which can be imagined to have been completely surrounded formerly by the younger series. Sandstones are exposed on the coastline for some 10 miles, and ragged reefs cut in them project offshore for a few chains at many points. The Notocene beds appear again in Kaikoura Peninsula and in the Amuri Bluff, in both of which places they have been planed by the sea at accordant levels. The narrow, recently built strand-plain, characteristic of the coast to the north of the Clarence, is not developed here, and road cuttings in the steep hillsides are numerous.

It cannot be supposed that this area has escaped the effects of the general movement of recent emergence, but no satisfactory record of former beach-levels is preserved in the harder rock. Evidence pointing to a very recent slight elevation of small amount may be summarized as follows. In Okiwi Bay boulder-beaches resembling three parallel tiers of railway-embankment suggest uplift

of 15 to 20 ft. On the south side of the bay a platform cut in the sandstone and having practically no surface cover, slopes down to high-water mark for about two chains. Uplift here might be as much as 20 ft. Slightly raised cut platforms occur almost continuously from this point to the Ohau Stream where there is a flat-topped remnant of a platform at 130 ft. Its surface-cover consists only of angular blocks and fragments of sandstone, but any water-worn material there may have been would not be preserved on this ledge.

In Halfmoon Bay there are low projecting spurs behind which the roadway has been cut. It may be suggested that these formed projections on the surface of a platform similar to the present wave-cut shelf on which are irregular low stacks. Here too are wave-worn caves, one continuous as a tunnel through the bluff at the south of the bay, the other containing a very large well-preserved log of drift-wood cast up by the sea in fairly recent time to a point beyond its present reach. Making all due allowance for the extent to which the floor of the caves may have been raised in various ways since the retreat of the sea, they certainly indicate an elevation of 10 ft. In making any inference regarding elevation of the land in a locality such as this, the observer must make all possible allowance for the power of the sea to cast up material into small exposed bays. Therefore, while the evidence afforded by raised boulder-banks may be misleading, that obtained from raised rock-platforms and water-worn caves may with more certainty be accepted as proof that uplift has recently taken place here to the extent of at least 10 ft. to 12 ft.

F. MAUNGAMAUMU BAY TO THE KAHAUTARA RIVER.

This section of the coast comprises the Kaikoura Plain extending from the southern side of Maungamaumu Bay to the mouth of the Kahautara River, and the low flat-topped hills of the Kaikoura Peninsula. The geology of the Peninsula has been fairly fully traversed by various writers and will not be discussed in detail here. The physiography of the area has also been discussed by McKay (1886, p. 126; 1890A, p. 182), Morgan (1916, p. 19), Park (1911, p. 523), and Cotton (1916A, p. 36). Cotton (1916A, p. 37) describes the Peninsula as an island "now tied to the mainland by the confluent deltas of several streams forming the Kaikoura Plain, where locally the shore line has advanced owing to a very abundant supply of waste from the Seaward Kaikoura Range," while McKay (*loc. cit.*) gives a lucid account of the manner in which this supply of waste has been built up into the great fans of the Kowhai and Hapuku Rivers, to form the Plain.

McKay (1890A, p. 98; 1892, pp. 12-14) describes a great fault-zone extending past the eastern base of Mt. Fyfe, through the valley of the Puhipuhi into the valley of the lower Clarence, and thence north-easterly to the mouth of the Flags River. Commenting on this, Morgan states (1916A, p. 20) that there are probably two parallel faults in the Puhipuhi Valley, and that, "There is certainly strong parallel faulting along the coast-line, as shown by the smashing and crushing of the pre-Quatenary rocks wherever they are exposed. Thus the essentially faulted nature of the coast line is

clearly demonstrated." He also draws attention to the fact that the rocks of Kaikoura peninsula are highly disturbed by faulting, a feature noted by McKay (1887, map, p. 76).

Cotton, unable otherwise to reconcile the projection of Kaikoura Peninsula with his hypothesis of a fault-coast, especially exempts this area from the full effects of the great fault, which is supposed to account for the peculiarly straight line of the rest of the East Marlborough Coast. He states (1916A, p. 36) "The initial island was probably the unsubmerged portion of an unevenly depressed seaward block."

No indication of the nature of the basement-rock below the delta-fan gravels of the Kaikoura Plain is afforded by examination of the valley of the Kowhai, but it is a reasonable conjecture that near the eastern base of Mt. Fyfe are remnants of the Notocene beds as are exposed in the valleys of the Puhipuhi, Hapuku, Kahautara, and thence continuously into the valley of the Charwell. The low hills to the west of the Kaikoura peninsula consist of greywackes, and the Notocene beds of the eastern portion, though highly disturbed by minor faults, exhibit a fairly simple folded structure. It may be supposed that after the close of the late Tertiary period of heavy faulting the whole of this area was depressed below sea-level, the highest point of the "island" being now only 358 ft. at the Trig. station behind the old wharf. On this hypothesis it is not difficult to account for the isolation of the "island" by the erosion of the less-resistant portion of the Notocene beds, as a wave-levelled plain emerged in stages to its present height. The re-uniting of the "island" to the mainland belongs to very recent geological time, and the whole series of changes since post Tertiary emergence began no doubt post-dates any major faulting that has occurred here, or at any other part of the north-east coast of the South Island which comes within the scope of this paper.

The terraced surface of Kaikoura peninsula has been noted by Cotton (1914A, 1916A), Morgan (1916A), and Henderson (1924, p. 586). Estimates of the heights of these terraces show considerable variation. The highest point of the upper terrace is 358 ft. as noted above, but as it is only a fragment of what it must formerly have been, the actual level of the period of standstill represented may be somewhat higher. The other two terraces offer more reliable evidence, they being cut in the seaward side of the peninsula at 250 ft. and 140-160 ft. respectively. Near the racecourse the latter terrace is a little lower than this, but its surface is not very regular here, and the writer is of opinion that the most nearly accurate estimate of the amount of uplift indicated by it is 150 ft. Morgan (*loc. cit.*, p. 20) notes the presence of a fluvio-marine terrace just north of the Hapuku River at 100 ft. This no doubt represents the cliffed north-eastern edge of the Hapuku fan. The writer noted the height of these cliffs on the road from Maungamaumu as 90 ft., but is not satisfied that they represent any period of standstill at this level. The cliffs on the face of a receding delta-fan of this type will show almost any variation in height, and no definitely-marine deposits were observed in any of the cliff sections.

The cliffing of the outer edge of the Hapuku fan has provided an enormous amount of material for resorting and transport by the sea, and this is entirely responsible for the enormous shingle-bank in the neighbourhood of Lyell Creek just north of the peninsula (Morgan, *loc. cit.*, p. 20). From high-water mark to the inner bank above Lyell Creek it is approximately 14 chains in width—i.e., almost twice the width noted by Morgan. It rises in a series of four terraces to a height of 21 ft. above high-water mark—i.e., at the summit of the inner terrace on which is the Main North Road. Taking the top of the first bank to represent normal high-water mark, the second terrace is 8 ft. above this, rising another 5 ft. to the rear of the third terrace. Two feet above this, on the face of the fourth or main terrace, a line of drift-wood marks the maximum height of storm-seas—i.e., 15 ft. above normal high-water mark. The main terrace, wide and undulating, rises to 21 ft. above high-water mark, and from its inner edge a steep descent is made to the bank of Lyell Creek, the bed of which is here only 2-3 ft. above high-water mark at a point about a mile from its entrance to the sea at the northern end of the township. Exceptionally heavy seas are sometimes experienced here, and much drift-wood has been cast high up on the terraced-face of the shingle-bank. The wave-force in this exposed bay must be very great, and with an inexhaustible supply of shingle from the cliffed fan of the Hapuku, the formation is readily explained. Once the first barrier was formed an object against which to cast the shingle would be provided, but infilling of the outer bay would cause the waves to break farther from the shore, and some of their power to cast up shingle would be lost. A decrease in the height of the seaward portion would therefore ensue. To infer recent uplift from such a bank is likely to be misleading.

The drift of shingle round the peninsula from the south is interrupted by a reef running out to sea for nearly half a mile at the junction of the limestone and the grey marl near the Maori village on the south side. The rock platform is loaded with drift on its southern side, forming a wide strand-plain and intensifying an appearance of recent elevation, while around the east head of the peninsula the platform is practically free from drift-material, and the sea reaches the base of the cliffs at many points.

Caves noted by Morgan (*loc. cit.*, p. 20), are found near East Head, they being eroded in flaky limestone. The entrance to the caves is in every case partly filled in with broken rubble from the roofs, but Morgan inferred from them elevation amounting to 10-12 ft. At the extreme north-easterly point of the peninsula cliff-recession still seems to be very rapid, there being here an almost level platform cut in the grey marl over half a mile in width. Yet between this point and the old wharf there is a strip of strand-plain 3-4 chains wide formed of two storm-beaches enclosing a lagoon-like flat. This, together with a wide storm-beach at the base of the cliff round the next point suggests considerable recent elevation. Near the old wharf, where the narrow road is built on an old beach of limestone pebbles with numerous included fragments of whale-bones, the roadway is being attacked by the sea which would soon reach the cliff base again.

The extensive rock-platforms indicate the enormous extent to which the peninsula has been reduced in area, but evidence that recent elevation has amounted to as much as 10 ft. to 12 ft. is not altogether satisfactory. It is probable that redistribution of waste from the seaward edges of the river-fans, over the highly-irregular surface of the cut platform, has been to a much larger extent responsible for the narrow strand-plain forming the site of the township and the Maori village. Unequivocal evidence of recent uplift amounting to at least 10 ft. to 12 ft. has been recorded from the coast immediately to the north, but the writer is by no means certain that the movement has been regularly continuous to produce the same amount of elevation at Kaikoura.

G. THE KAHAUTARA RIVER TO OARO BAY.

Although definite evidence of raised shore-platforms is absent from some miles of the coast-line from the mouth of the Kakautara River to Oaro Bay, a coast where greywacke and associated rocks are exposed in the steeply truncated spurs (see Cotton, 1916, Fig. 21, p. 45), complete continuity and approximate uniformity of the recent upward movement cannot be doubted. The raised beaches of the Kaikoura peninsula have their exact counterpart at and near Amuri bluff, whence an embayment of a former shore-line with well preserved terrace-remnants extends to the southern end of the Hawkswood Range near the mouth of the Waiau-ua River.

Cotton (1916A, p. 45) draws attention to narrowness or absence of the continental shelf with a great depth of water about two miles from the land. He states further, "This suggests recent subsidence along a fault line close to the present shore; and the land presents the appearance of a fault scarp (Fig. 21), as though a strip had recently subsided along an arcuate line a little within that of the initial scarp of the resurrected fault coast to the north-east that has already been described. A very similar result might, however, have been produced by offshore subsidence as a result of renewed movement on the original fault (if we may assume that the fault coast now recognized to the north-east formerly extended along this portion of the coast also). Such offshore subsidence would in most cases be followed by increased activity of wave action on the shore, producing a cliffed shore line not unlike that of a young fault coast. Further study in the field is necessary before a more definite statement as to the nature of this strip of coast can be made"

The present writer agrees that the later Tertiary faulting accompanying the Kaikoura orogeny had a profound effect on the topography of this area, and to a large extent determined the distribution of the Notocene beds. A study of the present occurrence of these throws some light on the physiography of the locality. Erosion at Oaro Bay has revealed the classic section at Amuri Bluff, which shows a gentle anticline with the Notocene rocks overlying a core of Jurassic sandstone. McKay's coloured map (1890) shows this sandstone to occur in a similar position at Kaikoura peninsula, though it must be admitted that the shaly rock forming the core of the main anticline there does not resemble the typical "cannon-ball" sandstone at Amuri Bluff. The Notocene beds are developed through

the valleys of the Oaro and Hundalee streams to the basin of the Conway River, and they occur again in the valley of the Charwell. In all of these localities they are disturbed by faulting, but they form an almost continuous strip around the base of a great protruding mass of greywacke and separate it from the main block of the Seaward Kaikoura Range. If recent faulting determined the outline of the present shore in the manner suggested by Cotton, then some evidence on a big scale might be expected in the neighbourhood of Oaro, the Hundalee Valley, and the Conway River. Such evidence as there is may be summarized thus:—

a. In the valley of the Okarahia Stream, between the Main North Road and the sea, greensands and sands overlie the Jurassic sandstone which forms the core of the Amuri Bluff anticline. Near the mouth of a tributary stream rising near the saddle over which the Main North Road passes into Oaro, is an exposure of Amuri limestone overlain by grey marl. These beds strike E. 10° N., dipping westerly at 30°. Faulting may be inferred from the repetition of the greensand in the section, this being exposed a little farther up the main stream, but the amount of displacement is not great.

b. In the valley of the Oaro Stream, near the school, limestone and overlying grey marl are seen to dip south-easterly in the north-western wing of the syncline which succeeds the Amuri Bluff anticline. Upstream behind the school greensands are exposed intermittently in the banks, the section being somewhat obscured by recent terrace-gravels. Then limestone appears again in an area disturbed and shattered by faulting The amount of displacement indicated by the repetition of the limestone is not remarkable. Grey marl containing fucoids is exposed for a considerable distance upstream, until the Hundalee conglomerate (so named here on account of its peculiar distribution in this locality) appears near the Okarahia-Oaro saddle. Morgan (1916A, p. 24) states that a fault determines the relationship of the conglomerate to the grey marl, but the section in the Okarahia Stream about to be described offers an alternative explanation.

c. A tributary of the Oaro Stream issues from a narrow precipitous gorge cut in greywacke to enter the main stream near the school. At the entrance to the gorge the greywacke is disturbed and brecciated, it being traversed by a steeply inclined normal fault running N.E.-S.W. No rocks other than greywacke are involved in the fault and the amount of displacement is difficult to determine.

d. Less than half a mile below the bridge across the Okarahia Stream on the Main North Road, greywacke is exposed in the steep banks for a distance of some 300 yards. There is a very clear contact between the greywacke and the conglomerate beds which are so clearly exposed in the road-cutting about 150 ft. vertically above. The junction is a simple unconformable contact, showing no sign whatever of disturbance by faulting, and the conglomerate consists here of small rolled pebbles of greywacke in a sandy matrix, with occasional large blocks of grey marl a short distance upstream

Immediately below the first road-cutting exposing the conglomerate, i.e., about ¼ mile from the bridge, another contact between the conglomerate and the greywacke is seen. Here the division-line

is nearly vertical, but the greywacke shows no sign of brecciation and the conglomerate lies undisturbed against it. Morgan (*loc. cit.*) states that a reversed fault occurs here. The conglomerate is certainly abruptly terminated against a steep wall of greywacke, but there is nothing to indicate that it was involved in any such reversed faulting subsequently to its deposition. The nature and distribution of these conglomerate beds have an important bearing on our study of earth-movements which may have affected the shore-line. While they contain numerous very large blocks of greywacke, Amuri limestone and grey marl such as those seen in the typical Great Marlborough Conglomerate, the bulk of the material consists of fairly fine well-rolled pebbles, and the sandy cementing medium is often full of shells and shell-fragments. In places the material passes into a sandy marl containing scattered pebbles, bands of gravel or large angular blocks. From examination of the Okarahia section the writer inclines to the opinion that its deposition post-dated any extensive faulting which may have determined the depression in which it appears to lie. There seems, however, no necessity at all to demand any large-scale faulting in explanation of its distribution, for it may merely have been deposited at the base of a cliff of normal marine erosion at a time when, with the land 1,000 ft. lower than now, the sea reached from the present Oaro Valley into the lower basin of the Conway behind Mt. Guardian and the Hawkswood Range.

This is a very useful and simple conception of its mode of origin, for the great angular blocks may now be supposed to have fallen from the cliff against which the beds were laid. There can be no doubt that the deposit is of marine origin, and that it is unconformable to the grey marls. Its Pliocene age is determined, too, by the evidence of fossils collected from the upper parts of it. Thomson (1912, p. 8) gives a list of fossils collected near Oaro, and determined by Suter to be of probable Pliocene age. Thomson, however, supposed these shells to have been contained in a raised-beach deposit, but Professor R. Speight has made collections from the upper conglomerate beds in precisely the same locality, and Suter identified these also as of Pliocene age.

There is therefore no satisfactory evidence that the great block-displacement which Cotton supposes to have determined the coast south of Kaikoura, is continued into the country near Oaro and the Pliocene Hundalee conglomerate does not seems to have been faulted into its present position. It is quite possible and likely that the conglomerate post-dates the Kaikoura orogeny and its present elevation above the sea can be accounted for by a post-Kaikoura elevation of about 1,000 ft., i.e., equivalent to the height of the upper marine terraces. The cliff against which the beds were laid may have been a fault scarp belonging to the Kaikoura orogeny but it is by no means necessary to suppose this.

So there is only the evidence of the fresh-looking steepness of the coastal cliffs and the occurrence of deep water close inshore to support Cotton's conception of a recent fault-coast north of Oaro. Examination of the coast-line concerned shows steep cliffs truncating spurs, the strata highly tilted and disturbed, abundant smoothed slicken-sided faces, and an irregular cut platform of considerable

extent. All these features, however, are to be found wherever masses of the older rock are cliffed at the shore-line. On both sides of the mouth of the Oaro Stream are remnants of Notocene beds terraced at 150 ft. and at 360 ft., but no remnants of them are found on the coast between here and Kaikoura, and there are no definite terraces in the older rocks. Since support for the hypothesis of recent large-scale faulting has not been found from examination of the adjacent land, it may be supposed that any such faulting as may have occurred was of the nature of a huge cauldron-like subsidence of the sea-floor some distance from the present shore. However, the cliffing of the coast by marine erosion at a time when the land was higher than now must not be overlooked as a possible explanation of the sudden deepening of the water offshore.

The writer has examined Cotton's description of the coast (1916A) in the field, but has sometimes found it difficult to follow. As far as the disappearance of the Notocene rocks from the coast is concerned, it will probably be found that such disappearance is a regular structural feature, and not necessarily to be attributed to faulting. The alternation of older and younger rocks is most remarkably regular from this point southwards, and recent faulting does not seem to have been a factor in determining the outline of the present coast.

H. OARO BAY TO THE HAWKSWOOD BLUFF.

With the exception of the well known section at Amuri Bluff, this locality has received comparatively little attention from geologists. Haast (1871) gives a general account of the structure of the district, indicating the succession of rocks down the coast from Amuri Bluff to the Conway River, and describing a section exposed in the north bank of that river. Buchanan (1868, pp. 38 and 40) makes brief reference to the structure at the mouth of the river, while McKay (1886, p. 126; 1890A, p. 182) states that he did not examine the terraces to the south of it. His coloured map (1890A), however, shows roughly the position of the gravel-beds there—gravels which he, for no expressed reason, assigns to the same formation as his "Great Post Miocene Conglomerate." Hutton's map accompanying his paper on the North East Coast (1877, p. 56) shows the rocks of his "Maitai Formation" exposed on the coast-line continuously between the Conway River and Gore Bay.

For the reason that much of this area has hitherto been unexplored by the geologist, and that it contains raised shore-platforms rivalled in extent only by the Motunau Plain, it will be described in some detail in this paper. In view of the fact that a University student has lately commenced a study of the geology of the lower Conway basin, the stratigraphical relationship of the coastal gravel-beds to those in the neighbouring Hundalee Valley, and to the associated richly fossiliferous sandy marls, will not be discussed.

McKay's coloured map (1890A) shows a threefold division of the older rocks in this locality—i.e., his Bastion Formation is represented in the core of the anticline in the Amuri Bluff section, his Otapiri and Wairoa Formations (Triassic) extends from the coast

at the Kahautara River across the Conway and Hurunui Rivers through the main mass of the Hawkswood Range, while the rocks exposed on both sides of the Waiau River are supposed to be of Maitai (Carboniferous) age. These latter rocks are the only part of the pre-Notocene series examined in any detail by the present writer, and any discussion of McKay's classification is beyond the scope of the present work. It may be noted, however, that his map is somewhat inaccurate regarding the areal distribution of the greywackes and associated shaly rocks which are exposed in the steep bluff where the Hawkswood Range is truncated by the sea some two miles to the north of the mouth of the Waiau River.

When the land was from 500 ft. to 900 ft. lower than now the Hawkswood Range determined the former shore-line with a wide, open bay to the north of the present bluff, which must then have had a considerable extension seaward. Emergence has exposed the local remnant of the Notocene "covering strata" in terraced flats filling the old embayment for a distance of 18 to 20 miles, and landward erosion of these younger beds has been interrupted by periodic renewals of uplift, and a more recent cycle of progradation near the mouth of the Conway River. The most striking feature of the present shore-line is that, although it formerly approached several times to or within a short distance of the arcuate base of the Hawkswood Range, it is now almost perfectly straight for a distance of some 18 miles from the Hawkswood Bluff to the mouth of the Okarahia Stream. The Notocene beds are divided into two very distinct localities by the Conway River—those to the north of it consisting of Cretaceous sands and sandstones overlain by the typical Amuri limestone and grey marl, while those to the south are only stratified gravels and massive conglomerates associated with sandy marls and sands all of a younger age. These localities will therefore be considered separately.

a. *North of the Conway River*: The Notocene rocks here form a narrow tilted strip lying close to the base of the pre-Notocene hills for a distance of some 7 miles and rising to a greater height in the eastern wing of the denuded anticline at Amuri Bluff. The sections exposed at the Amuri Bluff and in the north bank of the Conway both appear to be perfectly regular and undisturbed by faulting, and they both show a similar succession of sands and sandstones passing up into the Amuri limestone and grey marl. Haast (1871, pp. 37-39) described both sections in some detail and remarked (p. 39) on the complete disappearance of the Amuri Bluff beds in the southern bank of the river, they " being probably hidden under the large post-Pliocene shingle terraces which face the mountain sides, and which make their appearance again three miles south of the mouth of the Waiau-ua River, in a few cliffs washed by the surf."

In order to determine the relationship of the beds on either side of the river, continuous observations were made of the strike of the older Notocene beds exposed in the sea-cliffs from Amuri Bluff southwards. It is the strike of the Amuri limestone that is recorded, but this is discontinuous on the coast, it having sometimes been completely removed by marine erosion where the sea has cut

through it at many points into the underlying sands. Indeed in one locality about a mile north of the Conway River the whole sequence of the Notocene beds has been removed, exposing the underlying Jurassic sandstone in the graded cliffs.

At Amuri Bluff, strike is N.E., dip S.E. 30°. (Speight and Wild, 1918, p. 87.)

At the mouth of the Okarahia Stream (just south), strike is N.E. (true). Here the beds are disturbed, dipping very steeply.

Farther south at cliffs from the face of which the limestone has lately been removed strike is N.E. (true).

Near the Boat Harbour, strike is N. 40° E. (true).

In reefs exposed at low tide near Claverly strike is N. 15° E. (true).

At first point below Claverly strike is N.S. (true).

In the Conway River section strike is N. 60° E. Dip southerly 45° to 50°.

This indicates the irregular nature of the outcrop and the manner in which it swings seawards from the mouth of the Okarahia Stream, and then inland to the south of Claverly, exposing the limestone in the north bank of the Conway at a considerable distance from the present shore-line. It appears highly probable, therefore, that the gravels and fossiliferous sands and sandy marls exposed in the high cliffs between the Conway River and the Hawkswood Bluff lie in their normal stratigraphical position.

South of the Conway River: In February, 1927, the writer examined the beds exposed in the cliffs between the Waiau and Conway Rivers, and on the return journey ascended the terraces in the southern and central portions of the Hawkswood area, and examined the beds exposed in the ravine-like valley of the Medina Creek. The return trip from the Conway to the Waiau occupies two days and should be undertaken only when the sea is calm and the tide low in the late afternoon and early morning, so that the base of the Hawkswood Bluff may be passed easily.

The coastal section from the Hawkswood Bluff to the lower terrace near the Conway River shows the following:—

a. Shaly greywacke exposed in the magnificent cliffs of the bluff. The rock is in places very shaly but becomes more massive farther north. It generally stands in an almost vertical position and shows considerable contortion.

b. Light grey sandy marls lying with sharp unconformity on (*a*), and dipping steeply in a direction a little to the north of east. The first exposure is seen two miles north of the Waiau River. In the first stream dissecting the main Hawkswood terrace they are seen for a distance of only 200 yards, ending abruptly against the shaly greywacke. They form the steep sea-cliffs from here to a point near the mouth of the Medina Creek.

c. Conglomerates of medium to coarse texture composed of well-rounded pebbles of greywacke and associated rocks. The cementing medium is highly ferruginous, imparting a rich coloration to the cliffs even where these are freshly exposed by slumping, which occurs here on a large scale. Very good sections through them are seen in the almost vertical walls of the narrow gorge at the mouth of the Medina Creek.

d. Sands. These succeed the conglomerates in the cliffs a little to the north of the Medina Creek. They are in places richly fossiliferous.

e. Gravels, less firmly cemented than (*d*), appear again about 5 miles south of the Conway River. These beds become increasingly finer in grain with alternating layers and lens shaped inclusions of brown, grey and yellow sands, until near Mr. D. MacFarlane's homestead they consist entirely of sand.

The section through Medina Creek shows a succession of (*a*) conglomerates, (*b*) sands and sandy marls, (*c*) conglomerates. There appear to be two bands of conglomerate, one near the shoreline, the other near the base of the Hawkswood Range, and separated by thick beds of fossiliferous sands and sandy marls. Closely similar beds are exposed in the lower Conway basin, and the examination of these will no doubt reveal their true stratigraphical position.

c. *Shore Platforms*: Various writers have referred to the presence of raised beaches in this locality. McKay (1886, p. 126; 1890A, p. 181) noted the occurrence of recent marine shells at Amuri Bluff at a height of 500 ft., but he did not think that the terraces on the seaward slope of the Hawkswood Range are a continuation of those between the Amuri Bluff and the Conway River. He no doubt referred to the larger of the terraces on either side of the river, the connection between these being certainly not very clear. Hutton (1877, p. 55, and section 12) referred to the Amuri Bluff and the Hawkswood terraces, and noted a higher terrace cut in the older rock south of the Conway at a height of 300 ft. It is apparent that Hutton's estimates of heights of terraces were always very conservative—in this case only a little more than half the actual height. Thomson (1912, p. 8) noted fossiliferous sandy beds in the valley of the Oaro Stream at 900 ft. It has been pointed out that these may belong to an earlier period than the raised beaches of the locality, but there is other evidence of cut platforms at about 1,000 ft. with which the deposits noted by Thomson may perhaps be correlated. Morgan (*loc. cit.*) notes further the occurrence of terraces at 40 ft., 50 ft., and 200 ft., near the mouth of the Conway, at 400 ft. near Claverly, and at 600 ft. above the Amuri Bluff.

As there seems no reasonable doubt that the terraces on both sides of the Conway are continuous, no distinction between the two areas will be made in the following description of shore-platforms at various levels:—

a. *At high-water mark*: Redistribution of fine gravel and sand from the material of the Waiau and Conway Rivers and of the receding portions of the coastal cliffs, has obscured the platform cut at present level, except in the neighbourhood of the Amuri Bluff. The reefs of limestone exposed at low tide near the Boat Harbour and Claverly (Haast, 1871, p. 38) form a remnant of a platform, the inner edge of which is thickly mantled with sand and shingle; but from the mouth of the Okarahia Stream, round the Bluff to Tarapuhi, the platform is singularly free from surface cover. Where the component rock is the grey marl, it has a very uniform level surface, except where the strike of the beds is parallel to the shore and their upturned edges project in a system of parallel ridges.

Here the junction between the grey marl and the Amuri limestone is very clearly shown (Speight and Wild, 1918, p. 87) and where the harder limestone forms the material of the platform, it has a highly irregular surface, with ragged unevenly-cut masses of rock extending for some 150 to 200 yards from the shore. The junction between the limestone and the underlying sandstone is also very clearly exposed at the north side of the bluff, and where this passes down into softer sands, the platform disappears under a mass of coarse gravel cast up on the beach. The surface is traversed by deep narrow channels developed from cracks similar to that which has been enlarged by wave-action into the natural arch at the end of the bluff. The large area of the platform exposed at low tide, and the manner in which it has become covered with beach deposits in other places suggest that recent slight uplift has taken place, but there is nothing to mark definitely the extent of it.

b. *At 30-40 ft.*: Just south of Claverly the base of the high cliffs retreats inland where the Notocene rocks have been completely removed at some points. This embayment of the former shore-line is in every respect similar to that which now exists to the south of Amuri Bluff, but it has been infilled with fine shingle and sand, attaining a maximum height of somewhat less than 40 ft., and forming the terraced area known as the lower Conway Flats. Distinct terraces, of the nature of successive barrier beaches, can be traced right across this lower plain; they are somewhat better developed on the north side of the river. The heights of these old barrier-beaches may be summarized as follows:—

Taking the top of the first bank of shingle on the shore (6 ft.) to be normal high-water mark,

The second terrace is 10 ft. above high-water mark.

The third terrace is about 22 ft. above high-water mark. (The inner edge of this terrace is not more than this height above high-water mark, and it is 25 to 30 chains wide.)

The fourth terrace is about 35 ft. above high-water mark. This terrace is of more limited extent and is found near the base of the cliffs just north of the Conway River.

The slope of all these terraces is definitely inland. It is difficult to form even a rough estimate of the actual amount of the elevation indicated by them. It is probable that the seaward edge of each shelf represents an old shingle barrier, which formerly enclosed a lagoon similar to that now existing at the mouth of the river.

c. *At 50-60 ft.*: In the extreme southern corner of the lower Conway Flat, Mr. D. Macfarlane's "Rafa Downs" homestead is built on a remnant of a higher platform at 50-60 ft. This height may not actually represent the level of a former beach, for it is uncertain to what extent it has been raised by material from the grading of the gravel cliffs behind it. In the low cliffs at the present shore-line the beds exposed are fine gravels, sands and clays containing remains of tree-trunks. This is probably the locality referred to by Buchanan (1868, p. 40, and section p. 38) who describes the finding of erect tree-trunks and stumps in position, in a tough blue clay overlain by sands and gravels exposed in the high cliffs. All the logs seen by the writer were prostrate, there-

being no erect stumps. Buchanan's section (p. 38) showing stumps in position cannot now be seen because the shore-platform depicted in the section is thickly covered with recent beach-shingle and sand. It is of course quite possible that this cover may have accumulated since 1866, but the few prostrate tree trunks now visible are not admissible evidence of recent local subsidence.

d. *At 150-160 ft.*: This is the height of the inner edge of the terrace at Amuri Bluff (South), where it shows a well-planed surface with terrace-gravels and sands resting with sharp unconformity on a basement of grey marl. Just north of the Conway River, however, there is a very steep rise from the rear of the lower flats to a height of 180-190 ft. Here the 150-160 ft. level is apparently not represented. It is well developed on the south bank of the river where, however, its surface relief has been modified by the river and by drainage tributary to the river. Just north of the "Rafa Downs" homestead, the terrace terminates abruptly in a gently-graded cliff rising to a platform about 90 ft. higher. The discontinuity of this terrace level through the Amuri Bluff-Hawkswood area is very confusing in correlating the various remnants but it is easily explained, for with the land 150 ft. lower than now, there would be large irregular embayments of the coast in striking contrast to the peculiarly straight line of the present shore. At Amuri Bluff the inner edge of the terrace is obscured by fan-like accumulation of angular chips of limestone from the hill above, and there is an abrupt rise to the terrace standing at about 550 ft. On the south bank of the Conway, too, there is a still more abrupt, almost precipitous rise to a terrace at the same level, though a little farther south a remnant of the 250 ft. platform is preserved.

e. *At 250 ft.*: On the north bank of the Conway River, the cliff (180 ft.) which determines the inner edge of the lower Flats is the present seaward margin of a gently-sloping terrace which, when traced along the left bank of Limestone Creek, rises to 220 ft., being about 30 ft. higher on the right bank. This terrace extends northwards until it merges gradually into the 150 ft. level near Amuri Bluff. It is well represented in the Hawkswood area where it extends as far south as Medina Creek. Here a terrace rises somewhat abruptly from it at a level of 330-370 ft., but it appears again in an extensive platform near the Hawkswood Bluff. The discontinuous fragments of this 250 ft. terrace, too, have the general shape of segments of circles, bearing witness to the embayed outline of the former shore. Although a general view of the area may give a confused idea of considerable surface-irregularity, the inner edges of terrace remnants at 250 ft. can be traced for long distances, and the boundaries of the old embayments thus fairly well defined. This, together with the accordance in level of the 250 ft. terrace at Kaikoura, indicates that elevation was remarkably regular for many miles.

f. *At 330-380 ft.*: As noted above this terrace is well represented just south of Medina Creek, and its inner edge rises to some 380 ft. Morgan (1916A, p. 24) estimated the height of the remnant behind the Claverly homestead to be 400 ft., and discontinuous remnants of ledges at 330-380 ft. occur throughout the Hawkswood area.

Terraces at this level appear to have been entirely removed from the seaward face of Amuri Bluff Hill and the hills immediately south of the Conway River. The remnants in the middle portion of the Hawkswood area are now little more than a succession of flat-topped spurs separated by narrow deep channels of consequent drainage, which make communication a matter of great difficulty. Though definite remnants of marine terraces at this level are notably absent near the Conway River, there are saddle-shaped fragments of river-terraces with abundant water-worn pebbles on the surface. These occur on both sides of the river at about a mile from its mouth. Here the stream bed is 30 ft., and the terraces 400 ft. above the sea.

g. *At 500-600 ft.*: It is difficult to define the exact level of the marine terrace represented by a very large number of fragments between these limits. McKay's estimate of the height of beds of fossiliferous beach-shingle and sand on the Amuri Bluff Hill was 500 ft., while Morgan (*loc. cit.*) records similar deposits at an estimated height of 600 ft. The highest point in this locality (Tarapuhi Trig. Station) is 583 ft. Hutton, also, recorded the height of the well-defined platform cut in sandstone above the Conway River as 300 ft. This is an extensive and remarkable ledge. Its seaward face is about 550-575 ft. and its inner edge stands at 800 ft. The extreme seaward face, immediately above the river, is accordant in height with the Amuri Bluff Hill, and with a number of levelled spurs with water-worn pebbles on their surface extending from the north bank of the Conway River past the seaward face of Mt. Guardian. Many fragments of an accordant height are found, too, extending far to the south of the river, and the continuity of the spurs levelled at this height is very clearly seen from the summit of the southern part of the Hawkswood Range. Probably the most reasonable estimate of the terrace level represented by all these fragments is 550 ft.

h. *At 650-700 ft.*: As noted above, the ledge above the Conway River observed by Hutton rises from 550 ft. to 800 ft. The writer is of opinion that a terrace-level occurs between these limits but has not sufficient evidence to say how far this is distributed through the area under discussion.

i. *At 800 ft.*: Widespread remnants of a terrace at this level occur for several miles to the south of the Conway River. The remnants are now nothing more than flat ledges cut in the spurs separating the parallel consequent stream valleys. High on the seaward face of the Hawkswood Range, they are not easy of access. For this reason the writer has measured them only on the bank of the river above referred to, near Medina Creek, and on the southern part of the range a little to the north of the Waiau River.

k. *At 1,000 ft.*: A well-defined ledge at about this level occurs immediately above the 800 ft. remnant at the Conway River. There appear to be corresponding ledges in several localities on the seaward face of the Hawkswood Range, though the writer is not prepared to say that they are all accordant in height. Also the deeply-dissected country in the neighbourhood of the Okarahia Stream and Oaro appears to have had formerly a levelled surface. This seems to have been observed by Thomson and Cotton (Thomson, 1912, p. 8),

though the shells collected by them at about 900 ft. were contained in the Pliocene Hundalee Conglomerate, and not in a raised-beach deposit.

In the above discussion no pretence is made at completeness of treatment of an area which has hitherto received little attention, and which merits a more detailed survey. A very remarkably complete suite of marine terraces is preserved here, but correlation of the fragments and interpretation of the evidence has been made difficult by the discontinuity of the remnants throughout the area. Having found an explanation of this in the existence of former irregular embayments of the shore line, similar to that in which the material of the more recent lower Conway Flats has been deposited, more rapid progress was made in the work. Much remains to be done in examination of the higher level terraces to the south of the Conway River Here the recently elevated terraced country is traversed by deep ravine-like channels of consequent drainage and much time is occupied in reaching any small part of the area where the higher terraces are developed.

I. THE HAWKSWOOD BLUFF TO THE BLYTH RIVER.

A large inland basin infilled with Tertiary marine beds extends from the fault-valley of the Greta, across the Hurunui, through Cheviot, Spotswood, and Parnassus to the Conway. "The structure of this basin is dominantly synclinal" (Speight, 1918, p. 98). A greywacke ridge separates it from the sea, and through it the Jed and the lower Waiau gorges have been cut. Speight (*loc. cit.*, p. 99) describes the nature of the syncline into which the Notocene beds have been folded at Gore Bay, and indicates the manner in which it is followed to the south by an anticline with a core of greywacke at the lower Hurunui Bridge. This greywacke appears to be in continuation of the ridge extending across the lower Waiau from Hawkswood to the Jed; it appears again on the coast at Port Robinson and in Manuka Bay at the seaward base of Mt. Seddon, and disappears under the covering strata immediately south of the Hurunui Bridge. Greywacke makes its last appearance on the North East Coast at the mouth of the Blyth River, but it can be traced as the core of an anticline as far as the main branch of the Motunau River at a distance of five miles from the sea. The strike of these pre-Notocene rocks and the direction of the ridge are variable and generally not parallel to the present shore. The regular alternation of the older and the younger sets of beds on the coast-line obtains as far south as the Blyth, this being the point at which the older rocks disappear from the coastal cliffs. From here southwards, however, a precisely similar regular alternation of the older and the younger members of the Notocene series is the most striking structural feature of the coast.

The nature of the Gore Bay syncline has been amply discussed by Haast (1871, p. 41 and section 16), Henderson (1918, pp. 171-4), Speight (1918, p. 99), and Speight and Jobberns (1928), and the stratigraphy at the mouth of the Hurunui has been described by Speight and Wild (1918, p. 80), and Speight and Jobberns (1928). Therefore little further reference to the structural features of these

localities will be made in this paper, but a general description will be given of areas which have hitherto received little attention viz.:—(*a*) From Hawkswood Bluff to Gore Bay, and (*b*) from the Hurunui River to the Blyth. A correlation will then be made of the shore-platforms occurring on this part of the coast, indicating the very remarkable continuity and uniformity of former beach-levels.

a. *Hawkswood Bluff to Gore Bay*: In addition to the visit made to the mouth of the Waiau from the Conway, the writer also reached it along the coast-line from Gore Bay. Owing to the broken nature of the country, with its very steep rocky cliffs and boulder-strewn beach with impassable projecting bluffs, this trip, which was made in company with Mr. W. R. Robinson, proved very difficult. The waters of the Waiau formerly discharged into a small bay, filling it with fine shingle, sand, and silt, as exposed in the cliffed edges of the raised plain which now attains an average height of 40 ft. and covers an area of about 300 acres. The component material of the plain is in marked contrast to the coarser gravel now coming down the river to form the magnificent shingle-bank enclosing the lagoon at its mouth. Elsewhere high seas reach the base of the cliffs at almost all points between the Conway and Gore Bay.

Just south of the Waiau River mouth there is a small exposure of bluish-grey sand capped with dark yellowish gravels rising to 150 ft. About a quarter of a mile down the coast from the river, these sands show considerable distortion which has affected the overlying gravels as well, these being tilted very steeply from here to the first projecting bluff. At this bluff the ancient shaly sandstones are rendered almost schistose, and the beach is strewn with boulders of enormous size and masses of recent slip breccia consisting of fresh angular fragments. Just round the bluff to the south, the strike changes abruptly and the beds dip inland at a high angle, while from this point to the next bluff, which is impassable at the lowest tide, the rock changes to a more massive type of greywacke. When ascending this otherwise impassable bluff, the writer noted water-worn gravel on a fairly level surface at 370 ft. and again at 550-600 ft., while about half a mile below it are two very distinct gravel-capped remnants of a shore-platform at 350-400 ft. These are no doubt the terraces noted by Haast " three miles south of the Waiau-ua River" (1871, p. 39). From here to within about a mile of the Jed River the cliffs are very steep except where they have been graded somewhat by landslipping on an enormous scale. A characteristic feature of this slip-material is a hard re-cemented breccia consisting of sharp angular fragments of shale and sandstone imbedded in an earthy matrix of tenacious dark puggy clay produced by crushing of the shaly sandstones themselves. This material is somewhat resistant to wave-erosion and forms the material of a wave-cut platform on which are strewn irregular angular blocks and boulders of sandstone. This platform is more or less continuous along this coast, but its inner edge is obscured by angular debris from the cliffs and by shingle cast up to heights of 25 ft. in little bays. Some 2½ miles south of the Waiau River it is cut in a hard greywacke conglomerate with a very tenacious cementing-medium of dark-grey sand. Here, too, where the cliffs are more stable, are

remnants of horizontally-stratified marine deposits 30-40 ft. thick lying on the planed surface of shaly sandstone at about 150 ft.

Some three miles north of the Jed River, near the site of the wreck of the "Tainui" is an enormous stack-like block of compact grey sandstone, separated from the shore by a rock-platform cut in the typical re-cemented sandstone breccia. It is sharply distinct from the softer material of the platform—i.e., entirely foreign to the rock in which it rests, and its is probable that it reached its present position at a time of unusually active slumping, evidence of which abounds here. On a base measuring 2 chains by 2 chains and tapering only slightly to a height of 60 ft., it is a remarkable feature of the shore. Near its base, at a level barely above normal high-water mark, is a wave-cut ledge similar to the high-water platforms described by Bartrum (1916, pp. 132-134). Between here and the Jed River also the cliffs show unusually active slumping of a somewhat incoherent brecciated material, and the whole coastal area resembles a wide shatter-belt suggestive of recent powerful faulting. But the continuity of reefs extending 300-400 yards off-shore, the general non-resistant nature of the shaly rocks which are tilted into a nearly vertical attitude, and the presence of undoubted remnants of what once must have been a continuous raised shore-platform, indicate that rapid recession of the cliffs by wave-attack combined with seaward slumping on a great scale might satisfactorily account for this very extraordinary type of coast. The brecciation of the rocks is no doubt largely due to faulting, but there is no convincing evidence of any recent movement on a big scale.

b. *From the Hurunui to the Blyth*: Speight (1918, p. 99) notes briefly the peculiar surface-features of this locality, but the only other reference to it is that of Hutton who says (1877, p. 55), "At the north head of the Blyth stratified shingle, resting unconformably on the Pareora formation forms hills 500 feet high." No reference is to be found in geological literature to the enormous development of older stratified gravels, occupying the lower basin of the Blyth for a distance of 5 miles from the sea, and covering an area of some 20 square miles.

The rocks exposed at the eastern base of Pendle Hill, where the Blyth River issues from a deep narrow gorge cut in greywacke, are sands and marls overlain by massive shelly conglomerates and sands (Mt. Brown beds). These pass up into sands and sandy marls with the hard "cement stone" inclusions of the Motunau series which, however, have only a limited exposure situated about 5 miles from the mouth of the river. Here on the left bank high bluffs are found to consist entirely of stratified gravels dipping south-easterly at 15°-20°, resting against the soft sands of the upper portion of the Mt. Brown series, and capped unconformably by thick beds of horizontally-stratified gravels attaining a height of over 500 ft. In the bed of the river below the bluffs the contact between the gravels and the Motunau beds is not visible, but from their relative positions their unconformity is evident. This exposure is of considerable importance as it removes doubts as to the Mt. Brown age of the sands with hard calcareous bands exposed at the mouth of the Hurunui River (Speight and Jobberns, 1928), and it enables

the older gravels of the locality to be correlated definitely with the Kowai series of gravels (Speight, 1919, pp. 269-281) to which they bear a very close resemblance.

The sequence of Notocene rocks forming the south-easterly wing of the Hurunui Bridge anticline has been described elsewhere (Speight and Jobberns, 1928). Here the Mt. Brown beds lie unconformably on the grey marl and Amuri limestone, being themselves overlain unconformably by the older set of stratified gravels which, when traced southwards, are seen to have an enormous development. No doubt complete removal of the intervening Motunau beds and part of the upper Mt. Brown series preceded the deposition of the gravels in this locality. These gravels are well exposed in the cliffs just north of the Blyth, and magnificent sections through them are seen in the precipitous walls of the many ravine-like channels eroded here. The supply of waste, both as slip-debris from the cliffs, and water-borne shingle from these ravines, has far exceeded the capacity of the sea to remove it, so that an unusually wide strand-plain has developed in this locality. In these circumstances, however, it does not necessarily indicate any recent elevation.

On the south bank of the Blyth, near its mouth, the gravel-beds are seen to lie with sharp unconformity against the lower members of the Cretaceous series of sands and, where these disappear upstream, against the underlying greywacke which forms the core of the anticlinal ridge behind the Napenape beach. At the Hurunui Bridge, too, the greywacke and overlying Notocene beds involved in the anticline disappear abruptly beneath the gravels, and this anticline is at a much lower level than that of the Napenape ridge, and considerably out of alignment with it. Therefore the relation of the beds at the Hurunui Bridge to the similar beds at Napenape, and the relation of the gravels to the underlying rocks in the Blyth, together with their peculiar distribution and persistent south-easterly dip for several miles inland indicate that the valley of the Blyth has been determined by a fault with a considerable downthrow to the north-west. Since it is apparent that the gravels have not been involved in the movements affecting the underlying beds, it is very probable that their deposition proceeded after this faulting had taken place and the main structural features of the lower basin of the Blyth had been determined. The gravel-beds in contact with the greywacke on the south bank of the river have not been disturbed by faulting.

More recent movements have, however, profoundly affected the whole of the area. Prior to the deposition of the older gravels submergence of the eroded Notocene beds had accompanied the faulting above referred to, it being a most significant fact that the older gravel beds contain no fragments of rocks younger than greywacke. Therefore there seems very definite evidence here that the faulting, which was no doubt coincident with that which determined to a large extent the present physiography of Canterbury (Speight, 1915, pp. 336-353, 1926A, pp. 355-360), took place in the period intervening between the emergence and erosion of the Motunau beds and the deposition of the Kowai gravels. The subsequent history of the area has been one of general re-emergence with some slight

warping of the surfaces planed by the sea, but with no appreciable renewal of the major faulting-movements. Speight (1919, p. 281) assigns a Pleistocene age to the Kowai gravels where these are unconformable to the Motunau series. Therefore the emergence of wave-terraced Kowai gravels indicates very clearly the Pleistocene or later age of this upward movement.

Beds of more or less horizontally stratified shingle and sand form a surface-cap on the planed edges of the underlying tilted strata, these later deposits extending far up the valley of the Blyth where Hutton (1877, p. 55) observed them overlying the Mt. Brown sands. In some places near the coast they attain a thickness of 50-60 feet and are not notably different in texture or material from the tilted gravels on which they lie. Such a thickness of surface-cover suggests deposition on a slightly sinking surface after planation of the older gravels had commenced. Then ensued the period of discontinuous uplift affecting the whole coast and leaving wave-cut terraces at 150-160 ft., 250 ft., 330-350 ft., and 525 ft. Speight (1918, p. 99) notes that the wave-levellel surface south of the Hurunui is higher near the coast than farther inland. The highest point near the coast is 525 ft., whereas, at a distance of 3 miles from the seas it is only 300 ft. This peculiar regular concavity of the surface must be attributed to warping, and the manner in which all the streams flow south-easterly to the Blyth has no doubt been determined by an original tilt in that direction.

CORRELATION OF SHORE-PLATFORMS.

While the nature of the later Tertiary deposits in the Blyth Valley affords some definite evidence of the age of the emergent coast, there is preserved in this area bordering the lower Hurunui a very complete record of the stages by which an elevation of at least 800-850 ft. has been attained. The locality deserves a more accurate survey of the heights of the terraces than the present writer has been able to make, a survey which would define clearly the number of periods of considerable standstill during the uplift process and the exact heights of the inner edges of the terrace remnants. There is no other part of the north-east coast with the exception of the lower Conway area where such accurate work could be undertaken to greater advantage. The following is a summary of the terraces preserved between the Waiau and the Blyth Rivers.

a. *High-water mark*: Rock-platforms cut at present sea-level are generally obscured by beach-drift. They are, however, well marked at Gore Bay and Port Robinson, and less distinctly on parts of the coast north of the Jed as described above.

b. *At 40-60 ft.*: Terraces at this level occur at the Waiau mouth and on the north bank of the Hurunui near its mouth. In the latter locality the terrace is cut in the Notocene beds below the bridge, and capped with a thin veneer of sand and fine gravel. Traced in a north-easterly direction it shows a gradual increase in height where the surface-cover is increased in thickness by alluvial material from the seaward slopes of Mt. Seddon. In Manuka Bay, a small rock-ledge cut in greywacke stands at 40 ft. and this probably represents the actual height of the cut portion of the platform.

c. *At 150-160 ft.*: A number of terrace-remnants at this level occur discontinuously. One has already been described from the Jed-Waiau coast and small rock-ledges on Mt. Seddon stand at 150 ft., probably the most reliable estimate of the height. This is also the approximate level of the lowest terrace cut in the Mt. Brown sands and Kowai gravels between the Hurunui and the Blyth, but the surface of this platform is uneven and, owing to irregular accumulation of debris from the incoherent gravels and sands of the more or less maturely graded cliff behind it, its inner edge is by no means horizontal.

d. *At 250 ft.*: The second terrace in the Hurunui-Blyth area stands at this level, and it is in every respect similar to the one immediately below it. In the southern part of Gore Bay the terrace, out of the soft gravelly sands and clays of which the well known "Cathedral" has been eroded, attains a maximum height of about 290 ft. But here, as elsewhere, the inner edge is obscured by accumulation of drift-material, and the actual height of the surface planed by the sea is probably only 250 ft. It may be traced southward to Port Robinson, where Henderson estimates its height as rising from 220 ft. to 250 ft. (1918, p. 174; 1924, p. 587). A remnant at 250 ft. is seen to the south of Port Robinson, in Manuka Bay, but here its inner edge is very uneven and it appears to grade into a lower platform at 150-160 ft.

e. *At 330-350 ft.*: Discontinuous fragments of a platform at this level are to be found on the Jed-Waiau coast (previously described), on the seaward slopes of Mt. Seddon and immediately south of the Hurunui. In the last-named locality the height of the terrace on the south bank of the river near the bridge is 300 ft, but it becomes higher when traced southward to the Blyth, where, however, its inner edge is not well defined.

f. *At 500-550 ft.*: Fragments of a platform cut in the greywacke of Mt. Seddon at nearly 550 ft. may be correlated with the maximum height (525 ft.) of the gravel-ridge south of the Hurunui Bridge. It is difficult to determine exactly the level of the standstill represented, but it lies within the limits of 500-550 ft

g. *At 650 ft.*: Again on Mt. Seddon is a distinct bench cut in greywacke immediately above the Hurunui Bridge. Water-worn pebbles occur sparingly on its surface at 650 ft., but the origin of these is not certain. However, the occurrence of undoubted marine gravels at the summit of the hill strongly suggests that these too may have been beach-material, rather than river-shingle.

h. *At 800 ft.*: The Trig. Station (N) at the summit of Mt. Seddon stands at 784 ft. The surface is here thickly mantled with fine well-rounded pebbles and sands. That this is a beach-deposit may be accepted without any hesitation whatever, and it may be correlated with precisely similar material found above the Napenape cliffs at slightly over 800 ft.

The foregoing summary presents briefly the facts relating to a very complete series of terraces, and in it the writer has referred only to those remnants which preserve some admissible evidence of beach origin. Henderson, however (1918, p. 174; 1924, p. 586),

refers to raised beaches at Gore Bay at 12 ft. and 80 ft. above present sea-level.

The conditions in the immediate vicinity of the Gore Bay syncline where immensely thick gravels are exposed in steep cliffs now some distance from the shore, are precisely similar to those obtaining just south of the Hurunui. Accumulation of unusual quantities of debris in a sheltered bay at the base of such cliffs might be expected even on a sinking shoreline. It must be noted too that the Jed River is to some extent tidal, and that the waves are vigorously attacking the cliffs where the thick gravel-beds have disappeared from the southeasterly wing of the syncline. In these circumstances it does not necessarily follow that the wide strand-plain in Gore Bay and extending to the northeast past the mouth of the Jed River is any indication at all of recent uplift.

It is immediately north of the mouth of the Jed that the terrace at approximately 80 ft. is developed. This has a flat surface of considerable extent and is separated sharply from the hills behind it by the deep channel of a stream which, rising near the summit of Mt. Maccoinnich has its lower course parallel to the present shore line—i.e., the stream does not enter the sea directly but is tributary to the lower Jed. The terrace has a distinct slope in accordance with the stream, and the sharp angular material with which it is thickly mantled is distinctly not beach-shingle. There is no marine platform with which it may be correlated and it must be regarded as a purely alluvial terrace, cut by the lateral swing of a stream which had deposited thick beds of angular debris at the foot of a steep slope. It does not necessarily indicate a period of standstill at 80 ft.

J. THE BLYTH RIVER TO AMBERLEY.

Throughout this area the following succession of rocks is exposed in the steep cliffs of the coast:—

a. Greywacke, in the cliffs at the mouth of the Blyth (south bank)—its last appearance on this coast.

b. Sands. Yellow sulphur sands, greensands, etc. (Cretaceous beds).

c. Amuri limestone, exposed in the cliffs at Napenape. In the south bluff at this point the top of the cliff is formed of the overlying grey marl, but it is the limestone which forms the lower cliffs for some distance to the south.

d. Grey marls, a greensandy facies characteristic of this locality.

e. Arenaceous shelly limestone, passing up into brown sands, with hard calcareous bands (Mt. Brown beds), exposed on the coast immediately northeast of Stonyhurst.

f. Grey marly sands, soft brown sands, with typical calcareous "cement stone" concretions and bands, and occasional bands of shelly conglomerate. These comprise the Motunau series, forming the basement rock of the Motunau Plain. They extent from Stonyhurst to a point some 3 miles south-west of the Motunau River.

g. Mt. Brown beds, a repetition of (e). They extend from the south-western extremity of the Motunau Plain to near the north-eastern base of Montserrat.

h. Grey marls. i. Amuri limestone. j. Sands (Cretaceous series).	All these beds are exposed on the seaward face of an eroded dome to the north-east of Montserrat.

k. Amuri limestone forms steep bluffs where the Montserrat ridge is cliffed by the sea. (Jobberns, 1926, p. 226).

l. Marls. m. Mt. Brown beds. n. Motunau beds. o. Mt. Brown beds.	These complete the succession of rocks exposed between the Montserrat ridge and the Waipara River near Amberley.

This remarkably regular alternation of beds within the Notocene series has an important bearing on the distribution of the fragments of raised shore-platforms. The greywacke no longer determines the inner edge of the raised platforms, its place being taken by limestones —i.e., the more resistant members of the Notocene series. Often the whole Notocene sequence is revealed in sections taken at right angles to the shoreline, and the harder limestones may stand out above the general level in simple homoclinal ridges forming the hills near the coast. The strike of the limestone shows a more or less regular variation imparting a gentle S shape to the outcrop. The general dip of the beds is south-easterly, at low angles where the limestone swings inland, but somewhat more steeply where it swings out to the present shore-line. A definite anticlinal dome-structure is developed immediately to the north-east of Montserrat, and the ridge forming the Napenape hills is a simple denuded anticline. In these areas raised shore-platforms have a restricted development, but the intervening Motunau Plain with a structure dominantly synclinal, is perhaps the most remarkable feature of the north-east coast. Similarly, while an excellent record of former beach-levels is preserved at Dovedale (Jobberns, 1926, pp. 225-26), similar continuous platforms are not found between there and the lower Waipara River, in an area where the Mt. Brown beds are folded into an anticline over Bills Hill as shown in the map accompanying Speight's description of that locality (1912, p. 223).

The Napenape Hills: These comprise the anticlinal ridge above referred to, extending from the mouth of the Blyth to Stonyhurst, and attaining a maximum height of 1,100 ft. in Sail Rock. The general direction of the greywacke forming the core of the ridge is indicated by its appearance in the coastal cliffs at the Blyth and again on the Stonyhurst road some three miles from the sea. The succession of beds exposed on the coast has been indicated above, and here they dip south-easterly at the moderate angles of 15-20 degrees. Above Napenape beach the summit of the ridge is formed of the Amuri limestone and on the inner face of the ridge it is seen to dip north-westerly. Speight and Wild (1918, p. 80) observed old shore-platforms here with beach-gravels at an estimated height of 500 ft. Henderson (1924, p. 587) correlated this level with the surface of "plateau like uplands" above Port Robinson, though the general level of the hill-tops in this locality is 800-850 ft. At this height the writer observed beds of well-rolled beach-shingle covering distinct benches cut in the limestone directly above Napenape beach.

Below the Napenape bluff a terrace with uneven surface and undefined inner edge stands at the 150-160 ft. level ending abruptly in limestone cliffs at the shore-line where there are several isolated stacks of the same rock. To the southwest the hills slope gently down to the Motunau Plain the inner edge of which is obscured by drift-material. South of this point the usual complete succession of wave-cut terraces is not well preserved, but a 350-400 ft. level is strikingly represented by the Motunau Plain.

The Motunau Plain: This remnant of a formerly very much more extensive plain of marine denudation is some 12 miles long, and attains a maximum width of about 2 miles in the vicinity of the Motunau River, it having the shape of a thin segment of a large circle. About 1¼ miles off-shore at the river-mouth is an island, of 5 acres in summit-area and unquestionably a remnant of a once larger plain (Speight, 1912, p. 224). Although this area had attracted the attention of Haast (1879, pp. 366-67), Hutton (1877, p. 54), McKay (1881, pp. 108-18; 1883, pp. 74-79), and Speight (1912, pp. 222-24), references to its physiography have hitherto been of a more or less casual nature, being included in observations made during the progress of other work. The discovery of recent marine shells and moa-bones on or near its surface gave an indication of its age, but it may be noted here that a considerable variation in estimates of its height recorded by various observers has led to confusion in interpretation of the nature and extent of the recent elevation. It was largely on account of the difficulties arising out of interpretation of its surface-features that the present writer found it advisable to make a more extended investigation of shore-platforms in other localities. The Motunau Plain, however, is of such large extent, and has all the characteristics of a raised beach so well preserved, that it could well be taken as a type with which any similar shore-platforms in other parts of the world might be compared.

Geological Structure: Sections through the complete series of Notocene beds exposed in the Motunau River and in Boundary Creek some two miles to the north, show the Amuri limestone and the harder parts of the overlying Mt. Brown beds, standing out high above the weathered surface of the softer sands to form the hills immediately behind the plain. Except where the beds are puckered into minor folds at Boundary Creek and again just south of the Motunau River, their dip is uniformly south-easterly at low angles decreasing steadily seawards. The hills therefore are of the nature of simple homoclinal ridges, with broad depressions behind them eroded out of the softer underlying sands. Through these coastal hills both these streams have cut deep narrow gorges, to cross the elevated plain in narrow channels deeply incised in the younger Motunau beds. Excellent sections are thereby exposed; and as no complete record of these has hitherto been published, that along the Motunau is here described in some detail. The section through Boundary Creek shows a very similar succession of rocks except that here the Amuri limestone has thinned out somewhat (Speight and Jobberns, 1928), and thin beds of coal occur at the base of the series (McKay, 1881, p. 111).

Section along the Motunau River Valley: For convenience of description these beds have been traced up the river from the mouth, and the sequence therefore is given in descending order.

a. Motunau beds: Compact, grey, argillaceous, well-cemented sands are exposed in the base of cliffs just north of the right bank of the river at its mouth. These beds are richly fossiliferous, and accessible only at low tide. They pass down into thick bands of very hard conglomerate, chiefly composed of fragments of oyster-shells. Below these are thick beds of friable yellowish sands exposed over a distance of nearly half a mile, where another band of very coarse shelly conglomerate forms a reef in the bed of the stream. Below this are yellowish sands passing down into soft sandy marls with hard cemented inclusions. These beds dip at about 12 S.S.E., the dip being a little flatter at the mouth of the river.

b. Mt. Brown beds: The above beds pass down without any apparent break into yellow and brown sands with hard calcareous bands and concretions. The actual contact between the two sets of beds cannot be distinguished. The calcareous bands in the sands become somewhat coarser in texture upstream, and the sands pass down into thick beds of arenaceous limestone interstratified with loose brown calcareous sands. Abundant shell remains show on the weathered surface of the limestone.

c. Marly greensands: 25 ft. thick. These are probably the local representative of the grey marls.

d. Amuri limestone with nodular layer (Speight and Wild, 1918, p. 81): The Amuri limestone forms a steep scarp above the river, and is traversed by a fault with a downthrow of some 80 ft. to the northwest. In the vicinity of the fault, extensive slipping has occurred, and the stream-bed is strewn with large angular blocks of limestone.

e. Shales and sands: These attain a considerable thickness in the depression behind the limestone escarpment. They are incoherent yellow and grey sands, passing down into,

f. Basal grits: In thin beds containing fragments of stems of Auraucarioxylon.

g. Greywacke: Forming a low ridge in the north bank of the river at a distance of 3 miles from the sea.

The marly greensands, limestone and underlying sands all dip a little south of S.E. at 20°. The Motunau beds at the river mouth dip at not more than 10°-12°. McKay (1881, p. 111) gives a section through Boundary Creek showing an unconformity between his Pareora and Mt. Brown series. In Boundary Creek the beds above the marly greensand are puckered into a syncline near the old ford, and the contact between the greensands and the Mt. Brown beds has been described elsewhere (Speight and Jobberns, 1928), but there is no evidence of unconformity above this junction. The regularity with which the dip of the upper beds decreases towards the coast is a feature characteristic of the Motunau area.

From the hills to the coastal cliffs, a distance of about 2½ miles, the planed edges of the Mt. Brown and Motunau beds are capped unconformably with gravels and fossilferous sands of recent origin. McKay (1881, p. 110) did not give much attention to these beds.

He stated, however, that the terrace-gravels gave no evidence of a marine origin. While it may be conceded that the beds capping the lower terraces within the stream-valleys are all of alluvial origin, marine deposits with scattered shell remains extend right back to the base of the stripped dip-slopes of the Mt. Brown beds above the Motunau gorge, at a height of 360 ft. The nature of these surface-beds is revealed in a section through them where they attain a thickness of 50 ft., in a high cliff (250 ft.), to the south-west of the mouth of the Motunau River. Here the following beds are exposed (in ascending order):—

a. Sands, with greywacke pebbles.

b. Similar sands, with small well-rounded greywacke pebbles.

c. Limestone pebbles, flattened and of variable size, up to 4 in. in diameter. This bed has a variable thickness from 8 ft. to 20 ft.

d. Loose friable sands with scattered greywacke and limestone pebbles.

e. Clay, unstratified, unfossiliferous, not distinguishable from "loess" deposits, up to 30 ft. in thickness near the bank of the river.

f. Coarser beach-sands and pebbles with occasionally shell-fragments form a thin surface-veneer.

At various points nearer the mouth of the river and in the steep banks of some of the streams, the sands lying immediately on the planed edges of the basement Motunau beds are richly fossiliferous. The writer collected specimens from the cliffs above Motunau beach at 130 ft., from the cliffs on the north bank of the river up to 150 ft., and from the banks of streams north of the river up to 200 ft., Mr. E. W. Bennett, lately of the Canterbury Museum, found from examination of these that they were without exception recent species. Haast (1879, p. 367), and Hutton (1877, p. 54), noted the presence of these rich shell-beds, and McKay (1883, p. 74) excavated moa-bones from the surface deposits near Boundary Creek.

The Inner Edge of the Plain and the Old Sea Cliff: Although the inner edge of the plain is generally well defined, its surface is irregular, and precise measurement of the wave-levelled portion is a matter of some difficulty. Apart altogether from lack of uniformity of height due to irregular surface-accumulation at the base of the old cliff, a somewhat uneven elevation, probably due to warping, is obvious to the eye. The following is a summary of heights recorded from various points at the inner edge of the plain.

a. Remnants of platform in extreme south 400 ft.

b. Other remnants in vicinity, of variable height 350 ft.-400 ft.

c. Near the second stream south of Motunau River 400 ft.-450 ft.

d. South bank of Motunau River, above gorge 350 ft.

e. North bank of Motunau River, above gorge . 360 ft.

f. A series of sub-parallel hummocky ridges between the Motunau River and Boundary Creek, stand above the general level at varying heights, viz.:—(1) 400 ft., (2) 375 ft., (3) 360 ft., (4) 390 ft., (5) 400 ft., (6) 410 ft., (7) 375 ft.

g. Immediately to the north of Boundary Creek, near the Happy Valley homestead, the average of several observations is 475 ft. In the middle of the plain a reservoir stands on a low hillock at 425 ft. It was from this locality that McKay

excavated moa-bones from an unusually thick surface-cover of recent beds, and it is highly probable that excessive progradation of the former shore-line was a factor in the raising of the inner surface of this part of the plain above the general level.

h. North of Black Birch Creek near Stonyhurst, the inner edge of the plain stands at approximately 400 ft., but here too it may be safely assumed that the actual height of the wave-levellel platform was somewhat lower than this.

As all this area near the Happy Valley homestead must have formed the head of a wide embayment of the former shore-line along-shore drift no doubt brought to it excessive quantities of waste and to these deposits were added the detritus from the subsequent grading of the cliffs, advancing irregularly in alluvial fans, and a certain amount of fine wind-blown sand. Unfortunately the only sections in which the nature of the deposits formed after retreat of the sea might be exposed are in the steep banks of the streams, but in these the streams have cut terraces of their own, and capped them with material of a fluvial nature. It is therefore impossible to determine exactly the height of the inner edge of the wave-levelled platform except at a few points, and it is equally impossible to determine what allowance is to be made for subsequent superficial deposit.

The grading of the cliffs at the rear of the plain has been determined in a very simple manner by the dip of the limestones forming the coastal hills. It is in the Motunau beds and the upper less resistant portion of the Mt. Brown series that the greater part of the platform was cut, the harder limestones then determining the outline of the shore, as they will again if the present cycle of marine erosion proceeds without interruption of further uplift. The actual inner edge of the platform is seen in the hard arenaceous Mt. Brown limestone in the north bank of the river at the gorge, and the manner in which the steeper slope of the cliffs has been reduced to that of these harder bands in the tilted Mt. Brown beds is very clearly shown. Stream channels have been cut back headwards into the rocks of the graded cliffs, but only a few streams have cut gorges right through the hills. However, in spite of this dissection of the dip-slopes the general outline and regularity of the old cliffs are still well preserved, furnishing further evidence of the comparatively juvenile age of the plain.

The Juvenile Drainage System: A peculiar surface of the Motunau Plain is a broad depression extending in a direction almost parallel to the present shore-line from a point near the Stonyhurst Road to the vicinity of the Motunau River which has cut its lower course across it. It is because of this depression that the coastal portion of the plain appears to be somewhat higher than the middle. It may represent a channel in the shore-platform eroded in the direction of prevailing currents in a manner similar to that which has formed between Motunau Island and the mainland. It seems more probable, however, that it is a channel of surface-drainage established shortly after the initial emergence of the platform. If this is so it implies that emergence was attended by warping resulting in a somewhat greater elevation in the north, this being supported,

to some extent at least, by the manner in which the tributaries to the present stream almost without exception come in from that direction. Warping during uplift is also suggested by the fact that the Motunau River is tidal up to a point more than half a mile from its mouth, for it is difficult to imagine the capacity of this stream to erode its bed the necessary depth below high-water mark. Such warping, too, may account to some extent for the irregular nature of the inner edge of the platform as described above.

A sudden renewal of uplift, this being very rapid, brought about an abrupt change in drainage to the present system of parallel juvenile consequent streams, which have become deeply entrenched in the non-resistant basement-beds of the plain. Speight (1912, p. 224) describes briefly the character of these narrow gullies which dissect its surface, and by the precipitous nature of their walls make communication a matter of difficulty. Only those few which have cut gorges through the coastal hills are permanent in flow; some scarcely extend to the inner edge of the plain, while others are merely ravine-like gaps cut in the face of the cliffs.

One of the most remarkable of these smaller channels is the first to the south of the Motunau River, to which it was formerly a tributary when the land was some 160 ft. lower than now. Sea-erosion at the head of a small embayment has cut its course in two, and subsequent elevation has caused it to cut down to present sea-level in a trench with almost perpendicular sides and a width of less than two yards in its bed. The profile of the upper part of this channel shows two sharply distinct stages of cutting and the following indicates its nature precisely:—

Height of cliff at mouth .. .	265 ft.
Width in bed	3 ft.
Width at top	66 ft.
Slope of walls, upper portion (1st cut) ...	45°
Slope of walls, lower portion (2nd cut)	75°-90°

This shows that a very steep valley has been eroded within an older valley with more maturely graded walls. The head of this channel is in the surface of the plain scarcely a mile from the sea, so that the grade cannot be less than 300 ft. to the mile. The Motunau River has terraced its banks in at least three distinct stages, but the terraces are not continuous downstream, and with them ledges due to intermittent lateral swing of the stream may be confused.

Boundary Creek, too, shows the nature of these narrow channels of recent incision in a very striking manner. Though the bed of the stream is somewhat more than 150 ft. above high-water mark at a distance of less than two miles from the sea, and the velocity of the flooded stream therefore very great, it follows a remarkably winding course in its bed. In the almost vertical walls of the valley the dip and strike of the beds appear to change abruptly at every turn, the actual dip being uniformly south-easterly at a low angle throughout the lower part of its course.

Despite the fact that in the surface of the plain evidence of pauses in the emergence process is not preserved, there is other evidence that the uplift by which the wave-levelled portion of the

inner edge of the platform was raised to its present height of 350-400 ft. was intermittent. A pause at 150-160 ft. is sufficiently clearly indicated, while another at 250 ft. can reasonably be assumed from its regular occurrence in neighbouring localities. However, the most valuable evidence afforded by this area is that of quite recent emergence, as indicated by the remarkable features of a very juvenile drainage-system.

Marine Erosion and Motunau Island: Speight (1911, p. 224) states, " This plain of marine denudation once extended much farther seaward, and the small island at Motunau is a remnant of it, its flat top showing a marked alignment of its surface with that of the coast-line opposite. How far this plain extended seaward it is impossible to say at present, but at the mouth of the Waipara the river terraces appear high above the present level of the water, and are terminated suddenly when they reach the edge of the old marine cliff which marks the edge of the coastal plain."

Motunau Island appears to owe its preservation as a remnant of the plain entirely to the protection afforded to its base by a massive reef of conglomerate such as that exposed near the mouth of the river immediately opposite. It is situated 1¼ miles from the present shore, and the channel is not deep though the s.s. Ripple is reported to have passed through it at high tide dragging her anchor. This distance indicates a considerable rapidity of erosion of the non-resistant rocks at Motunau, there being further measurable evidence of its rate. In a landslip resulting from the earthquake of Christmas Day, 1922, an enormous mass of debris was piled up at the base of a bluff between the mouths of two stream channels. In a few months this had been completely removed by heavy seas, and some 3½ years later the writer observed that the cliff-base itself had receded some 18-20 ft. The late Mr. Byrch of Motunau Station informed the writer that he had observed erosion amounting to one chain in ten years, which would agree very well with that just noted. The protective effect of the hard conglomerate in the base of the cliffs just north of the river-mouth is seen in the very distinct projection of the coast-line at that point, but immediately opposite the Motunau Station homestead the cliffs are receding rapidly in spite of some accumulation of drift material at their base. The manner in which the island became isolated is indicated by a similar recession of the cliffs in the small bay south of the river, to the tidal portion of which the sea will ultimately cut its way and separate a block of considerable size from the mainland.

There can be no doubt that the plain formerly extended far beyond the outer edge of Motunau Island, and that its emergence belongs to quite recent geological time. In view of the rapid rate of cliff-recession observable here, however, there seems no need to suppose that any agency other than normal marine erosion has been responsible for its reduction to its present size. This question, having an important bearing on the present outline of the north-east coast, will be referred to subsequently in this paper.

Motunau Plain to Montserrat: In a previous paper (1926, pp. 225-26) the writer referred to the very abrupt change in the strike of the limestone of the Montserrat range as it swings round almost

at right angles to continue through Vulcan Hill to the Motunau River. In the course of other work (Speight and Jobberns, 1928) the structure of a considerable portion of the adjacent country has been examined, and in the light of this further knowledge of the area it becomes more apparent how this abrupt change in direction of the limestone outcrop has had a profound effect on the topography of the coast. In the extreme south of the Motunau Plain the sandy marls typical of the locality pass down into Mt. Brown sands and limestones, and opposite the Mt. Vulcan homestead the underlying marls and Amuri limestone are exposed on the coast in a limited area which has suffered considerable disturbance and dislocation. Immediately behind the coastal ridge, of which the highest peak is Mt. Vulcan itself (Trig. P, 1,342 ft.), capped with a layer of Mt. Brown limestone dipping south-easterly at a low angle, is a broad valley eroded in sands of Cretaceous age. These sands form the core of a denuded anticline which terminates southwards at Montserrat, it being succeeded to the north-west by a corresponding syncline of which Montserrat and Oldham Peak in the Mt. Cass Range form the two wings (Speight and Jobberns, *loc. cit.*). On the coast at the point where the strike of the Notocene beds changes so abruptly is an immense landslip exposing the grey marly sands which here lie immediately below the Amuri limestone. This area of slip represents a large dome-like structure, which has collapsed where the steeply-dipping beds of limestone on its seaward face have been completely broken through. Immediately to the south the Amuri limestone attains a great thickness in Montserrat (1,492 ft.) and forms steep white cliffs on the coast-line. The structure of the Dovedale area is dominantly synclinal and here are preserved remnants of at least three distinct shore-platforms at 650-700 ft., 350 ft., and 250 ft. (Jobberns, 1926). On the face of the Montserrat dome described above, evidence of shore-platforms is not well preserved though the writer noted beach-shingle at 360 ft. and level surfaces at about 500 ft. In the broad floor of the valley eroded in the Mt. Vulcan anticline, a tributary of the Motunau River has carved a precipitous ravine nearly 150 ft. in depth, indicating recent abrupt elevation of that amount.

Montserrat-Amberley: The only addition the writer wishes to make to his published description of the Dovedale area, is to note the effect of very recent faulting on the shore-platform known as Bobs Flat. Though the inner edge of this platform is uneven, it attains an average height of 350 ft., and it is upwards of half a mile in width. Its seaward edge is remarkably straight, and it would appear that it is succeeded at a lower level by a platform of very irregular surface. Close examination of the surface marine beds of recent deposition shows that the platform has been traversed by a small and very recent fault with a downthrow amounting to approximately 120 ft. The subsidence of the downthrow block is somewhat irregular, and accounts for the uneven surface of the lower ledge. The fault scarp, however, is remarkably uniform and scarcely dissected at any point. This is the only locality on the north east coast in which recent faulting can actually be seen to have affected shore-line topography, the area involved being very small.

Shore-platforms to the south of the Dovedale area have all been cut in the Mt. Brown beds, which form the coast from here to the Waipara River. The writer has previously referred (1926) to terraces at 150-160 ft., and at 650-750 ft., and Speight (1912, p. 224) notes the existence of a remnant just north of the mouth of the Waipara River at 250 ft. This corresponds in height with a fragment in the Dovedale area. It appears, then, that although the evidence is necessarily fragmentary and discontinuous, terrace levels at approximately 150 ft., 250 ft., 350 ft., 500 ft., 650 ft., and 800 ft. persist throughout the whole length of the north-east coast from the White Bluffs near Blenheim to the mouth of the Waipara River, and at some points remnants of terraces at levels higher than 800 ft. are to be seen, though a good state of preservation of these is not to be expected. Remnants at lower levels, up to about 50 ft., also occur discontinuously, but wherever seen they are found to have resulted from brief pauses within the later (150 ft.) emergence.

The nature of the major structural features of the coastal country has been described in as much detail as has been considered necessary. The essential structural features of the lower Waipara area can be seen at once from the map accompanying Speight's description of that locality (1911). Here the Mt. Brown beds are seen to form a simple anticline over Bills Hill succeeding the syncline traversed by the road from the Waipara Railway Station to Dovedale. In North Canterbury, at least, it is very clearly seen that extensive shore-platforms are well preserved only at intervals on the coast, and that these represent the areas of which the structure is more or less synclinal. The writer would suggest tentatively that this may arise from a simple dome- and basin-structure, into which the Notocene beds have been folded, and which determines their present distribution on the coast—this structure being revealed where it is transected by the shore. No pretence is, however, made at completeness of treatment of coastal stratigraphy, which would demand far more time than the writer has been able to devote to the study. The remainder of the paper will be devoted to discussion of the possible effects of the emergent process on the Canterbury Plains and Banks Peninsula, and of certain theoretical questions which have necessarily arisen.

Part 2.

A. Gaps in the Evidence of Continuity of the Platforms, and the Fault Coast Hypothesis.

While the main purport of the foregoing part of this paper is description of the coast with special reference to shift of the strand, it becomes necessary to discuss various matters relating to similar phenomena recorded from other parts of the world. A great deal of the literature relating to post-Tertiary geology in Europe and America has not been accessible to the writer, but most of the relevant material available in this country has been consulted, including the comprehensive summary and synthesis of modern geological opinion on Quaternary geology made by Osborn and Reeds (1922, pp. 411-90).* No attempt will be made at correlation of the heights

*See also symposium on "Le Stratigraphie du Quaternaire" in 18 Session of Congrès geologique international, 1922, pp. 1409 and on (1926).

of terraces occurring on this part of the coast with those in other New Zealand localities—this already having been done, as far as is at present possible, by Henderson (1924, pp. 580-99). Before anything thoroughly satisfactory may be done in this respect many of the earlier and more casual estimates of terrace-levels occurring throughout our literature will have to be revised in the field. The possibility of correlation with terrace-levels in other parts of the world will, however, have to be considered, and in the light of recent advances in the knowledge of Quaternary geology in Europe and America, certain tentative suggestions will be made relating to our later Tertiary and post-Tertiary stratigraphy. Before these various matters are considered it will be necessary to discuss the possible effects of the emergence on the physiography of the Canterbury Plains and Banks Peninsula. At this stage, too, it is desirable to explain that though the writer has now become convinced of the continuity and uniformity of the process of emergence throughout the area extending from the White Bluffs to the Waipara River, there are certain gaps in the evidence which must not be overlooked. The absence of convincing evidence of high-level shore-platforms on portions of the coast, viz.:—*a*. Waipapa point to Maungamaumu Bay, and *b*. Kahautara River to Oaro Bay, has already been pointed out, these being two localities where the older rocks are exposed at the shore-line. With regard to the former, a well-defined cut platform at 10-15 ft. or more is almost continuous, and a platform cut at present sea-level is represented by extensive offshore reefs. These offshore reefs, too, are a feature of the Kahautara River-Oaro Bay coast, though here the cliffs are very fresh looking and more precipitous and a raised platform is not distinct.

Notwithstanding the unequivocal evidence of uplift preserved in the younger flanking rocks of the lower Clarence Valley, Kaikoura Peninsula, and Amuri Bluff, and the complete accordance in level of the terraces of the two latter localities at least, the absence of corresponding high-level terraces in the intervening areas is very marked. It cannot be due to any considerable extent to the resistance of the harder rocks to planing by the sea, because a succession of well-defined and extensive ledges has been cut in hard greywacke in other localities. Therefore it may perhaps be suggested that:—

a The Lower Clarence, Kaikoura Peninsula, and Amuri Bluff areas have been elevated, while the intervening masses of older rock have remained stationary.

Or *b*. The apparently unterraced blocks have subsided after a general uniform elevation.

Or *c*. Post Kaikoura faulting with subsidence to complete submergence of the seaward portions of two entirely distinct blocks has drowned the evidence of any terracing that there may have been. Elevation on the landward side only of a coastal fault-line would have the same effect.

It may be admitted that any of these explanations is possible but (*a*) and (*b*), implying such sharply differential vertical movement of adjacent earth blocks, are at least very unlikely, and are unsupported by any visible evidence from the field. In this connection it is most important to recall that in the almost precisely similar

Hawkswood Bluff-Gore Bay area, there are only small fragments of raised beaches more or less fortuitously preserved, but sufficient to prove definitely that the terraces of the Conway are to be correlated with those of the Hurunui, and that more or less uniform uplift was continuous from the Waipara River to Amuri Bluff. Further, the accordance in level of the terraces of Kaikoura Peninsula and the Amuri Bluff is so remarkable, that it becomes almost inconceivable that these places emerged to their present height by a movement which left the intervening coast unaffected, or that this latter block of older rocks was subjected to any subsidence which drowned a face terraced at corresponding levels. Admittedly there is evidence of disturbance by faulting at Oaro, but the Notocene beds, involved in the syncline succeeding the Amuri Bluff anticline, lie against the Greywacke block and show no sign of the extensive dislocation such a differential movement would demand.

There remains the alternative of the fault-coast hypothesis which has been put forward by Cotton (1916A, pp. 20-47), but which on examination in the field is found to be unsatisfactory, in some respects. The present writer, however, being concerned with the hypothesis only insofar as it may affect the continuity of the coastal platforms, does not propose to traverse it in detail.

South of Kaikoura Cotton sees a "young one cycle fault coast." The conception of a huge cauldron-like subsidence of the sea-floor seems to accord very well with the occurrence of deep water close inshore, and with the general appearance of the cliffs on the coast, and an easy way out of the difficulty would be to suggest that such downward movement occurred late in Quaternary time to an extent sufficient to submerge any portion which may have been terraced in accordance with Kaikoura Peninsula and Amuri Bluff. The present writer, however, has found no more tangible evidence to suggest such extensive faulting later than the main Kaikoura orogeny, though it is well known that many of the Marlborough faults are still alive, and this orogeny may perhaps be considered to be still in progress.

For the establishment of an "hypothesis of regional uplift following faulting," north of Kaikoura, Cotton attaches considerable importance to the fact that the so-called "Clarence Delta" was "built out upon the seaward block"—i.e., across the line of the hypothetical fault which had predetermined the line of the coast. This idea seems to have been based on a misconception of the structure of the "delta," and certainly on a misconception of the age of its component gravel-beds. Three miles from the sea these gravels are involved in a great reversed fault which must belong to the Kaikoura orogeny, and if the marl-beds at Otu Kaku Point—i.e., the extreme seaward point of the northern half of the "delta"—are equivalent in age to the "greymarls" of Deadmans Creek, then the gravels of the "delta" may be regarded as equivalent in age to the Great Marlborough Conglomerate.

Further, any such fault-coast hypothesis is faced with the problem of explaining the existence of the Kaikoura Peninsula in its present position; but since here the regional uplift is considered to have post-dated the faulting, the question of the possible removal of terraces does not arise. Cotton met the difficulty by supposing

that the subsidence of the seaward block has been differential and that it stopped short of Kaikoura Peninsula. Whether this was the case or not, there is a close accordance in level between the terraced summit of the Peninsula and remnants of shore-platforms and river-terraces in the Clarence-Kekerangu area. On this part of the coast, too, it does not seem reasonable to suppose that these areas emerged as the result of an uplift which left the intervening greywacke block unaffected. This participated at least in the most recent stage of the emergence.

While discussing the fault-coast hypothesis, however, it may be remarked that Cotton appears unable to credit the capacity of the sea to erode the coast until only fragments of shore-platforms and river-terraces (at 500 ft.) remain. The rate of erosion is measurable at Motunau, and must have been prodigious at Kaikoura, as also on almost the entire length of the coast, where offshore reefs are widely distributed and extend far out to sea. Taking into consideration the generally non-resistant nature of the rocks concerned, and the strong probability that the shore was similarly cliffed by erosion when the general level of the land was considerably *higher* than now, this difficulty is largely removed.

He suggests further that the transection of the harder and softer rocks by the present straight shore-line is strong evidence in favour of the hypothesis; but it will most probably be found that this alternation of harder and softer rocks is a simple structural feature of the coast, and that while the major platforms cut in the softer rocks in ancient embayments have generally been reduced to fragments, those of much lesser extent cut in the protruding faces of the harder rocks have been removed completely. At a time when the land was some 500 ft. lower than now, the shore-line was gently sinuous with quite pronounced salients of harder rock, as it will be again if erosion at present sea-level proceeds without interruption.

B. THE CANTERBURY PLAINS.

The general nature and essential structural features of these plains have been surveyed elsewhere (Jobberns, 1927, pp. 88-96). In that brief summary the writer put forward the views of Haast (1863, pp. 1-63, 1879, pp. 396-406) and further elaborated by Speight (1908, pp. 16-43; 1911A, pp. 420-436; 1911B, pp. 408-20; 1917B, pp. 361-364; 1926B, pp. 363-368), views which will be somewhat modified in this paper. Hutton (1884, pp. 449-54; 1877, pp. 56-58; 1905, pp. 465-72) maintained always that the present surface of the plains was produced by the levelling of the sea—but nowhere, except on their extreme outer margin is there any visible tangible sign of a former strand-line. All the gravels exposed in the high terraced banks of the upper valleys of the large rivers like the Waimakariri, Rakaia, Ashburton, and Rangitata appear to be entirely alluvial in origin, and the succession of wide arched ridges and corresponding depressions typical of alluvial fan-structure is complete. It is a structural feature that an accurate contour-survey of the surface would only show more clearly. Speight, too (1908), gives an extremely lucid and apparently altogether satisfactory account of the terraces so well developed in

the major rivers, stating that they are entirely due to the terracing of alluvial fans when decrease in the supply of waste to the rivers enlarged their capacity to cut.

In spite of this, however, it is inconceivable to the present writer that the movement of emergence so distinct, continuous, and equable extending from White Bluffs to the Waipara River, ended abruptly near the northern edge of the Canterbury Plains. Hutton's opinion will therefore have to be reviewed, but it is equally inconceivable that the present surface features of the plains—i.e., the perfectly regular succession of alluvial fans with corresponding inter-fan depressions—were produced by the waves of the sea. Mr. H. W. Harris, Resident Engineer to the Waimakariri River Trust, recently called the writer's attention to abnormal accumulation of shingle in the bed of the Waimakariri immediately below White's Bridge, at a point where the grade of the river is not more than two feet per mile, and where hitherto sand was the only deposit in the bed of the stream. The shingle-advance, dating from a moderate flood of 1926, has piled up a large bank of material across the river—material containing pebbles up to 4 inches in diameter. In the immediate neighbourhood is a deposit of small well-rolled pebbles of beach-shingle with shells, situated some 4 miles from the shore and at a height of 8 feet above sea-level. Therefore on the narrow coastal strip fringing the plain, where the grade is only about 2 feet per mile over a width of 4 miles, coarse shingle can now be seen advancing downstream, and it can be imagined that this might in the course of time completely obliterate the fragmentary traces of a former strand-line preserved here. Conditions are not quite the same, however, as they must have been formerly, for since the joining on of Banks Peninsula to the mainland with the consequent deflection of the powerful northerly current round the Peninsula, progradation by the sea has greatly increased the width of the fringing plain in this locality.

Whether the present abnormal drift of shingle downstream is due to increased supply from the mountains or to lateral cutting of the terraced gravel-banks in the higher plains may be a matter of dispute, but it is unimportant here. The capacity of the river to obliterate traces of the sea is demonstrable, and it becomes reasonable to assume that although no part of the present surface of the higher plains was ever washed by the sea, and all the gravel exposed in the terraced banks 400 ft. high (where the plain surface is about 1,000 ft.) may be entirely alluvial, the gravel under-structure of the plains emerged from the sea in harmony with the coast to the northward. The emergence itself would entail vast increase in the supply of waste to the already overloaded streams, and the advancing fans may never have been cliffed to any extent if at all.

The thickness of the gravels comprising the plains is immense, nearly 2,000 ft. being penetrated by the Chertsey bore without contact with the underlying solid rock. Chertsey, however, is some 380 ft. above sea-level at a distance of 12 miles from the shore, and it is here that the alluvial fan-structure is most clearly shown—the enormous fan of the combined Rakaia-Ashburton being transected by the shore-line in steep cliffs upwards of 100 ft. in height. Hender-

son, however, notes (1922, p. 12; 1924, p. 593) that below 1,500 ft. of gravels are oxidized sands and clays to 1,800 ft. below sea-level, quoting this as evidence of depression. That the land was depressed far below a former level is indicated by the topography of Banks Peninsula, but its re-emergence must have been more or less in harmony with that of the rest of the coast to the north.

The writer has made no examination of the terraces of the major Canterbury rivers and therefore does not know whether there is any close correlation to be made between them and the raised shore-platforms. That they appear to be cut in entirely fluvial material need not affect the general conception of the re-emergence of the plains in stages corresponding to those recorded from the immediately adjacent north-east coast.

Extending from the mouth of the Waipara River to the neighbourhood of Saltwater Creek is a marine terrace at a comparatively low height, already described by Speight (1912, p. 222, and map p. 223), and Jobberns (1926, p. 226). Its undulating surface, covered with sand dunes in the south, ranges in height from scarcely above sea-level in certain swampy areas to about 30-35 ft. near the base of the low cliffs behind it. To estimate the amount of Recent uplift it actually represents is exceedingly difficult, for much of it is no doubt due to simple progradation arising from alongshore drift of alluvial sand and shingle from the Ashley, Kowhai, and Waipara Rivers. The writer, however, recently excavated the semi-fossilized base of a skull of a large whale from the bed of the Kowhai River some two miles from the sea near the base of the cliffs, at an estimated height of 20 ft. above present high-water mark. The low cliffs disappear to the southward near Saltwater Creek, but this does not necessarily indicate decrease in amount of recent emergence in that direction; for as Daly (1920, p. 250) remarks, "along young coastal plains, sea cliffing might not have taken place systematically at all." As noted above, undoubted marine grits occur near Whites Bridge at the Waimakariri, as they do also just north of Kaiapoi near the Main North Road, being in both places about 8 ft. above sea-level. It must be observed, however, that both the Waimakariri and Saltwater Creek are tidal streams. The former was probably capable of eroding its bed in the lowland fringing the shore, somewhat below high-water mark, this being less likely in the case of the latter. Saltwater Creek has silted up considerably in recent years, but this may perhaps have attended settlement and cultivation of the land. The amount of recent emergence becomes definitely measurable again at Redcliffs and Sumner, where it amounts to 15 ft. above high-water mark. To say that a raised strand-plain extended from the mouth of the Waipara River to Sumner is perfectly reasonable, but whether its emergence was uniform cannot be known. The nature of the lower courses of the Waimakariri and Saltwater Creek suggest irregularity.

C. BANKS PENINSLUA.

The recent emergence of 15-20 ft. referred to above did much to complete the joining on of Banks Peninsula to the mainland.

Haast (1863, pp. 49, 52; 1879, p. 367) recorded evidence of raised beaches at Sumner, and on the south side of the Peninsula, and the writer has noted caves with finely stratified clay up to 15 ft. at McCormick Bay, caves with shells embedded in stratified clay at the north end of Sumner township, and at Monck Cave in Redcliffs; and caves at the base of cliffs now far removed from the sea and definitely above high-water mark in many other parts of Redcliffs and Sumner. The wide plain on which Redcliffs township is built, and the plain filling Sumner Valley, however, were no doubt formed largely of sand drifting down with the current from the Waimakariri, and the extent or present surface-height of these is by no means necessarily a measure of recent elevation of the land. This progradation combined with a slight elevation of the land effected the filling in of a shallow sea and the junction of Banks Peninsula to the mainland quite late in Quaternary time.

The present topography of Banks Peninsula indicates enormous dissection of the land when deep valleys were cut in the resistant volcanic rock in all parts except on the immaturely dissected slopes of Mt. Herbert. The land must formerly have stood at a much higher level, the evidence for which has been summarized by Speight (1917A, pp. 385-7). Drowning of the river-valleys and submergence of the calderas of Lyttelton and Akaroa resulted from subsequent depression. For the reasons here stated, the present writer believes that this depression was to a level at least some 800 ft. lower than now, and that subsequent emergence has only partially restored the land to its former level.

a. From Table Mountain at the head of Charteris Bay, a narrow tongue of land terminating in Potts Peninsula runs out into Lyttelton Harbour. This shows a succession of rocks from the basal sandstones through several types of rhyolite to the fine grained basalt of Mt. Herbert. The inner edge of this is an almost perfectly flat surface of considerable summit-area, rising gently to the steeply cliffed face of Table Mountain. This level surface at about 800 ft. is perfectly accordant in level with similar flat surfaces on either side of Gebbie Pass, by which Lyttelton Harbour is now separated from Lake Ellesmere. Though apparently complete absence of ordinary beach-material from these levels must be admitted, no other explanation seems possible than to assume that they represent remnants of a wave-cut surface formed at a time when the sea divided the island into two separate parts. When Gebbie Pass was submerged the northerly currents would sweep through here, and it is most improbable that any water-worn pebbles of the constituent rock of the island would be retained on the cut platform.

b. The foreland on which the Godley Head Lighthouse is situated has an almost perfectly levelled surface rising gently inland from 450 ft. to 475 ft. or a little higher. Speight (1908, p. 32) has previously referred to this as a surface possibly produced by marine erosion. It may be suggested that the absence of a definite cliff behind it is an objection to this view of its origin, but the erosion of gently-sloping flows of lava over a comparatively short period might not necessarily result in cliffing. For the same reason it is

somewhat difficult to estimate the exact level of a period of standstill in which it was produced. It was probably of 475-500 ft. Levelled spurs of accordant height are seen on the opposite side of the harbour entrance at Port Levy.

In accordance with this level are several large caves at a height of about 500 ft. above the sea in the head of the valley above the Redcliffs Rifle Range. One of these is very large, and one is definitely an ancient blowhole. On the floors of all are abundant shell-remains, but these serve only as evidence of former Maori occupation of them.

c. Scarborough, above Sumner Head or Whitewash Head, is a similarly-levelled spur standing at the lower level of 350 ft. Its surface is remarkably uniform, and there can be little reasonable doubt that the general regular emergence of the coast extended to this point as well. It should be noted, too, that the majority of the spur-ends between Port Levy and Long Lookout Point are definitely flattened at about this level.

It has prevously been suggested (Speight, *loc. cit.*) that certain of these levelled spur-ends may be admissible evidence of former submergence of the land to their level, but the writer cannot but believe that they correspond more or less completely to the shore-platforms from other parts of the coast, and that a thorough examination of the Peninsula and correlation of the levels from different localities will prove this beyond doubt.

D. A CORRELATION WITH SOUTH EUROPEAN PLATFORMS.

Converting the heights of marine terraces recorded from Western Mediterranean coasts by de Lamothe and quoted by Osborn and Reeds (1922, p. 423) into feet, for the purpose of comparison with those determined on the north-east coast of the South Island by the present writer, we have the table of comparison given herein. The writer desires to point out, however, that it was not until some time after most of the field-work for this paper was completed that any possibility of close correlation with the terraces of Europe or elsewhere was considered, and that therefore no attempt has been made in the field to see how far the heights of the European terraces apply to those of New Zealand. The results of the writer's investigations were arrived at quite independently, and all that is now being done is to set them out for comparison with the levels recorded by de Lamothe. Also, while the heights of the terraces have been defined within comparison narrow limits by de Lamothe, this has been impossible with the methods employed by the present writer. For this paper, the measurement of heights lower than 50 ft. has been made from normal high-water mark with the Abney level, while for greater heights the measurements recorded are all barometric. Two Aneroid barometers were used, these having been adjusted to the standard barometer in the Christchurch Observatory over a considerable period. Since inaccuracies may arise with the most careful use of the barometer, and since it has generally been found difficult to determine exactly the position of the inner edge of the wave-levelled portion of terraces, the writer has often not defined their heights locally within 50 ft. or so. With this explana-

tion, a table of comparison with Western Mediterranean levels is given below.

New Zealand (South Island). (Jobberns).		Mediterranean. (de Lamothe).
a. 40- 60 ft.	Pleistocene or Quaternary	60-66 ft. (Monastirian Stage).
b. 120-150 ft.		92-98 ft. (Tyrrhenian Stage).
c. 230-250 ft.		181-198 ft. (Milazzian Stage).
d. 330-380 ft.		295-328 ft. (Sicilian Stage).
e. 500-525 ft.	Pliocene?	486 ft.
f. 650-700 ft.		670 ft.
g. 800-900 ft		870 ft.
h 1000-1200 ft. (estimated)		1075 ft.

In the section of the New Zealand coast under discussion the highest level (*h*) is represented by the even sky-line of the summit of the Vernon Range (Cotton, 1914, Fig. 3, p. 288) and by the higher terraces in the Hawkswood area. If this even sky-line is shown to be the result of wave-levelling, then 1,000-1,200 ft. is only a rough estimate of the level of standstill represented. Apart from this, however, the correspondence in the number of sufficiently well-defined stages in the emergence of this part of the New Zealand coast with those recognized in the Western Mediterranean is exact. There is also a fairly close accordance in the heights of the terraces representing each stage, an accordance, however, which will probably not prove to be much more exact from the use of more precise methods of measurement. It is the definition of the inner margins of the terrace-fragments to be measured which presents the greater difficulty in accurate observation of this New Zealand coast. Furthermore, the variation in height can be shown to be due, to some extent at least, to local irregularity of uplift. So even with the most precise methods of measurement of heights, they cannot be defined within the narrow limits assigned to those of Europe, and if their uplift is not simply eustatic this is not to be expected.

E. A CORRELATION WITH SOUTH AMERICAN PLATFORMS.

A remarkable parallel to the later emergence of New Zealand is to be found in Darwin's account of the geology of South America written nearly a century ago. From his investigation of both the eastern and western shores of the continent he found abundant material which bears a close resemblance to that just described from this comparatively small section of the New Zealand coast. With a minimum of speculation as to probable cause, he records the traces of the emergence in precise measurement of the present heights of former beach-levels extending through several degrees of latitude, and though the area examined by the present writer comprises some 2½ degrees of latitude only, the number of pauses in the elevatory process and the present heights of the corresponding terrace remnants agree very closely with the data collected by Darwin within approximately similar latitudes on the other side of the Pacific.

His stated object in recording precisely the elevation of the terraces, the marine origin of which was generally indicated unequivocally by the abundance of Recent shells in surface deposits was,

"To show the remarkable equability of the recent elevatory movement." He notes, further, "The extension of the 330-350 ft. plain is very striking, being found over a space of 500 geographical miles in a north and south line." Then follows a summary of terraces occurring at this level, extending from the Gallegos River to New Bay—i.e., throughout latitudes 43° S. to 52° S. There is a similar record of terraces within the 200-300 ft. limit (generally 250 ft. where measured height is recorded), ranging from Coy Inlet to Bahia Blanca—i.e., through latitudes 39° S. to 51° S. "The extension moreover of the 560 to 580 and of the 80 to 100 ft. plain is remarkable, though somewhat less obvious than in the former cases. Bearing in mind that I have not picked these measurements out of a series, but have used all those which represented the edges of plains I think it scarcely possible that these coincidence in height should be accidental. We must therefore conclude that the action, whatever it may have been, by which these plains have been modelled into their present forms, has been singularly uniform."

He records, too, a plain at 840 ft. at the mouth of the Santa Cruz, "extending horizontally far to the south." "On the three lower ones, namely, those of 100 ft., 250 ft., and 350 ft. in height, existing littoral shells are abundantly strewed, either on the surface, or partially embedded in the superficial sandy earth. By whatever action these three lower plains have been modelled, so undoubtedly have all the higher ones, up to a height of 950 ft. at S. Julian and of 1,200 ft. (by estimation) along St. Georges Bay."

In order to avoid unduly lengthy reference to Darwin's account of the western coast of South America, the island of Chiloe may be taken as typical, it lying almost exactly within the same limits of latitude as the part of the New Zealand coast under discussion. Here he records quite recent elevation up to 10 ft., and immense shell-beds on a tableland at 350 ft. Also near Castro, "three distinct terraces are seen; the lowest was estimated at about one hundred and fifty feet in height, and the highest at about five hundred feet, with the country irregularly rising behind it; obscure traces, also, of these same terraces could be seen along other parts of the coast."

Except that the terrace at 80-100 ft. developed on the eastern coast of South America is represented in our New Zealand area by one at 120-150 ft., the correspondence between the various levels is most extraordinary. It is, in fact, the most striking coincidence encountered by the present writer in the literature consulted on the subject, and there is an equally striking coincidence in the latitude of the areas involved.

The table of correlation of terrace levels may therefore be extended as follows. In adition to the levels set out in it for comparison, a terrace of Recent emergence and attaining a height of only a few feet has been recorded from all of these localities. It is a curious fact that such well-developed terraces in this extensive series have been recorded from comparatively restricted areas, but in the absence of any definite statements that the *series* is not developed on coasts nearer to the equator, it can only be suggested that latitude is a factor determining their distribution.

New Zealand. (Jobberns).	South Europe. (de Lamothe).	South America. (Darwin).
a. 40— 60 ft.	60— 66 ft.	No record.
b. 120—150 ft.	92— 98 ft.	80—100 ft.
c. 230—250 ft.	181—198 ft.	200—250 ft.
d. 330—380 ft.	295—328 ft.	330—350 ft.
e. 500—525 ft.	486 ft	500—580 ft.
f. 650—700 ft.	670 ft.	No record.
g. 800—900 ft.	870 ft.	840 ft
h. 1000-1200 ft. (estimated).	1075 ft	950 ft.
		1200 ft. (estimated).

[Since this paper went to the printer, the writer has received, by the courtesy of Dr. A. V. Krige, a copy of his paper on changes of sea-level in South Africa (1927), a review of which appeared in the Geological Magazine of May 1928. Much of Krige's paper is concerned with the recording of data relative to the last stage in the process of emergence—*i.e.* the 20 ft. beach which is found over a wide area in South Africa. He has also abundant evidence of the existence of a beach at 50-60 ft., but he has not defined the heights of the higher terraces noted within narrower limits than 100 ft. or so, and his paper therefore does not indicate whether there is enough evidence in South Africa for a correlation of the upper terraces with those of New Zealand, South America, and Europe—a correlation which might have been expected if they are really a function of latitude as has been suggested by the present writer. It is important to note, however, that Krige sees evidence of depression (submerged river-valleys) existing side by side with evidence of elevation. He also records the existence of submerged ledges on the Agulhas Bank in an area where the 20 ft. and the 50-60 ft. raised beaches, at least, are strikingly developed. All this suggests strongly that in South Africa as in New Zealand the level of the land was probably considerably higher than now, but there does not yet seem to be available anywhere sufficient evidence to assign a cause to the vertical movements of the shore-line which seem to have been remarkably regular in widely separated localities.

Krige follows Daly in offering a simple eustatic explanation of the emergence of the lower terraces, particularly the 20 ft. beach. There may indeed have been a eustatic negative shift of sea-level world-wide in its effects, but it is only the last visible incident in a series of changes which the eustatic hypothesis in itself seems not competent to explain. The withdrawal of sea-water to form the Pleistocene ice of the higher latitudes might conceivably result in the exposure of a terraced Agulhas Bank which would be drowned again on the return of the water to the sea. But this certainly does not and can not explain the existence of raised beaches in Europe, South America, and New Zealand, for if so, these should not form a regular suite extending to hundreds of feet *above* the present shore-line, but should be in the position of the submarine ledges of the Agulhas Bank, submerged by the return to the sea of the water from the melting of the Pleistocene ice-caps.

Where evidence of depression exists side by side with evidence of elevation, the differential vertical movement of adjacent earth-blocks at once suggests itself as an explanation (as in the case of the "downthrown block" of the Marlborough Sounds), but there may, after all, be no necessity to suppose this to be always the case. Eustatic movements of ocean-level resulting from the loading of the Polar regions with ice might expose terraced shores only to drown them again as the ice melted. Therefore the level of the land in the areas exhibiting the higher shore-terraces must also have changed, quite apart from these eustatic fluctuations of sea-level, and it is possible that this too may have been connected with the excessive loading of the higher latitudes in Pleistocene times. In this connection two simple hypotheses suggest themselves, though there is at present little enough evidence to justify them.

a. The loading of the Polar regions with Pleistocene ice, in addition to causing a temporary world-wide lowering of sea-level may have resulted in a general depression of the areas affected, a depression from which these areas have as yet only partially recovered. It would therefore be quite reasonable to expect certain areas to show evidence of this depression as well as the more obvious evidence of a later elevation.

b. Enormous accumulation of Pleistocene ice about the Poles might conceivably have resulted in such depression of the Polar regions as would cause actual elevation of certain latitudes—a distortion from which the affected areas have been recovering by a general downward movement of land-level.

Whatever form such regional movements, if any, may have taken in adjustment of the earth's crust to loading and unloading of the Polar regions, it seems necessary to suppose some such movement in order to account for the suite of terraces recorded in this paper. Only the lowest members of the series of terraces can possibly be explained by abstraction of sea water to form the existing Polar caps, and any terraced coasts which may have been exposed during the periods of maximum Pleistocene glaciation should now be submerged, if eustatic fluctuations of sea-level were the only effect of successive making and melting of Polar ice.]

F. THE USE OF MARINE TERRACES IN DEFINITION OF THE LIMITS OF THE NEW ZEALAND PLEISTOCENE.

Not the least interesting aspect of the correlation of terrace-development in New Zealand with that of Europe and South America is consideration of the evidence which may be afforded regarding the age of our younger sedimentary rocks. Our geological literature contains no very definite statement as to the limits of the Pleistocene formation or of the age of the Kaikoura orogeny which has had such a profound effect on the present physiography of the country. The most comprehensive modern survey of the local Tertiary stratigraphy is that of Thomson (1916, pp. 28-40; 1917, pp. 397-413; 1919, pp. 289-349; 1920, pp. 322-415). We are here concerned only, however, with the beds assigned by him to the post-Notocene—i.e., his Notopleistocene. He says (1917, p. 411), "As we have no evidence that the highest Notocene stage, the Castlecliffian, corresponds exactly to

the youngest Pliocene rocks of the Old World, it is undesirable to use such a name as 'Quaternary' for the superficial rocks such as raised beach deposits, alluvial gravels and loess, of which all we know is that they are post-Castlecliffian, or even only that they are subsequent to the main Kaikoura deformation affecting the area in which they occur. It is still more undesirable to attempt to distinguish between Pleistocene and Recent deposits in New Zealand, where the fossil mammalia on which these distinctions have been based are not found."

He says further (1920, p. 412), "The Greta transgression was brought to an end by earth movements which caused tilting of the marine Notocene rocks in North Canterbury, and during the subsequent erosion the terrestial Kowhai beds were deposited. Finally came the major block faulting of the Kaikoura orogenic movements, by which all the Notocene beds were warped or tilted and the Southern Alps and Kaikoura mountains came into existence as high ranges. The subsequent history comes into the Notopleistocene. . . ."

Speight (1919, p. 281) says, "Therefore all that can be definitely stated is that the Kowai series overlies undoubted upper Pliocene beds and must be of a later age, and is most probably Pliestocene. This must be earlier than the gravels forming the Canterbury Plains, for these have suffered no deformation by folding movements, whereas the gravels of the Kowai series are at times folded somewhat acutely. They would therefore antedate the last period of glaciation to which the region had been subjected."

Marshall (1912, pp. 31-2; pp. 47-50) includes in the Pleistocene raised beaches up to 1,500 ft. (Preservation Inlet), the glacial moraines, peat swamps with moa bones, and gravel deposits up to 1,000 ft. high (Moutere Hills). He states, too (p.50), "The early Pleistocene was a period of great elevation and it is at once suggested that this too was the period of ice advance."

Park (1910, pp. 182-250) includes in the Pleistocene the major glacial deposits of New Zealand and mentions raised beaches up to 500 ft. He also (1911, pp. 520-4) includes gravel-deposits in Marlborough which appear, however, to be of much greater age, and not necessarily of glacial origin.

Henderson (1924, p. 580) says, "The land was at one time 1,000 ft. or more higher than it now is, but later was depressed till the old strand line was submerged to 1,000 ft. or more below its present level. The deposits formed prior to and during this depression are here considered of early Pleistocene, and those of the succeeding elevation of younger Pleiostocene age. . . . The deposits of the last mentioned (120 ft.) depression and subsequent elevation form the bulk of the Recent deposits of New Zealand." That is, Henderson regards the whole series of terraces from 120 ft. up to 1,000 ft. as younger Pleistocene, post-dating the glacial deposits.

Benson's summary (1921) of the recent advances in New Zealand geology indicates that little agreement exists as to the limits of the Pleistocene, and as to the age of the main Kaikoura orogeny (pp. 63-73). His suggestion (p. 66) that the Great Marlborough Conglomerate might possibly be correlated with the Kowai gravels described by Speight will be discussed in a subsequent paper.

From the foregoing summary of modern authoritative opinion on our later Tertiary and Quaternary geology it is seen that there is little agreement as to definition of the limits of the Pleistocene, and no satisfactory means of determining exactly what portion of the post-Tertiary deposits are to be regarded as Recent.

In the Old World, however, remarkable advances in the study of Quaternary geology have been made within the last decade. The present position is stated in the concise summary of Osborn and Reeds (1922, pp. 470-2, and Fig. 13). One of the most notable features of this advance in European geology is the correlation of marine platforms with the time divisions of the Quaternary. It has been shown above that the correspondence in the number of stages of the emergence of this part of the New Zealand coast and that of southern Europe is exact, and the accordance in level of the terraces quite remarkably close. It is most probable, therefore, that they must be more or less contemporaneous in both hemispheres, and if the validity of the use of marine terraces in time-division in Europe be sustained, then it may reasonably be applied in New Zealand. It must be remembered, however, that it is only this correspondence in sequence and level of terraces found on a comparatively small section of coast-line, which the writer has himself examined with considerable care, with those recorded by de Lamothe over a considerably greater area in Europe that is established in this paper. The validity of Depéret's (1918-1921) methods of broader classification and correlation of glacial and marine features cannot be discussed with reference to any material available in this area.

On the assumption, therefore, that the limits of the Pleistocene period in Europe are to be defined by the marine terraces ranging from the Sicilian Stage (90-100 metres) to the Monastirian Stage (18-20 metres), and that there is every probability that the similar terraces at corresponding levels in New Zealand are coincident in time, we would be provided with a more exact means of fixing the limits of the local Pleistocene.

It has been pointed out above (Part 1) that gravels which may be correlated with the Kowai gravels of Speight and which have hitherto been assigned to the Pleistocene have emerged in marine terraces up to 525 ft. On our present assumption as to the limits of the Pleistocene all these would then be regarded as Pliocene, and as they seem, too, to post-date the main Kaikoura orogeny, this deformational process would be of somewhat greater antiquity than hitherto supposed. In the present state of our knowledge of the glacial period in New Zealand, any attempt at correlation with marine terraces is impossible. New Zealand geologists are agreed as to the post-Tertiary age of our major glaciation, and Depéret includes practically the whole of the European glaciation within the Pleistocene, associating the Glaciation 1 (Scanian) with his terrace of 100 metres.

If, therefore, it can be established that the 350 ft. terrace is in New Zealand a measure of the lower limit of the Pleistocene, and established that the Kowai gravels (pre-glacial) are to be assigned to the Pliocene, then some advance is made towards a more definite knowledge of the age of our later Tertiary rocks.

Since the completion of this discussion of the division of Pleistocene time in New Zealand the writer has read Morgan's paper (1926, pp. 273-282) on the same subject. Morgan (p. 277) appears to have foreseen the possibility of some attempt at correlation of the Pliestocene in the Southern and Northern Hemispheres being "based on a study of the ancient strand lines." He summarizes clearly the present state of our knowledge of Pleistocene glaciation as it affected New Zealand, but there is nothing in the paper incompatible with the suggestions for precise division put forward by the present writer. Our knowledge of the glacial periods, locally, is still so far from complete as to render any attempt at their correlation with shift of sea-level quite impossible. The validity of the present writer's suggestions must depend on the validity of Depéret's correlations in Europe, and on the validity of regarding the marine terraces of both hemispheres as contemporaneous.

G. THE EUSTATIC HYPOTHESIS.

After collection of all the data with reference to marine terraces available in our New Zealand literature Henderson (1924, p. 591) states, "The above facts support the suggestion that New Zealand has moved in respect to sea-level during later Pleistocene and Recent times as a whole. Any differential movements between adjacent earth blocks that may have taken place during these periods must have been small, if compared to the plateau forming movements by which New Zealand has been uplifted as a unit."

With reference to the "Post Kaikoura Movements," Cotton (1916B, pp. 318-19) says, "It is important to note, however, that these latest movements generally have the effect, as far as any particular district is concerned, of "regional" as distinguished from differential movements—of epeirogenic as distinguished from orogenic. In a broad sense, however, these movements really are differential, for the New Zealand region has not moved as a whole. Units of much larger size than the blocks associated with the Kaikoura movements have moved independently. . . . It would seem that, though the Kaikoura movements may possibly be not quite extinct, they have very generally been succeeded, after a period of rest, by movements of the mysterious purely vertical kind which appear to have no connection with compression."

Many modern geologists believe that movements such as these are world-wide and are eustatic—the primary cause of marine transgression being the actual elevation of sea-level—and this view is supported by the great weight of the authority of Suess (1906). A belief in the eustatic hypothesis is also the basis of Depéret's correlations of marine terraces with alluvial and glacial features in Europe (1918-1921). The extent to which these views may be tested with reference to the coast-line surveyed by the present writer is limited, but the revelant facts which have come under his notice may be summarized thus:—

a. The sequence and heights of the terraces ranging from sea-level to 800 ft. or so may be regarded as being continuous from the White Bluffs to the Waipara River. There is sufficient evidence that

the emergence affected Banks Peninsula to approximately the same extent.

b. The inner edges of the terraces, when traced over several miles (Motunau Plain), are not regular in height. Uneven elevation attributable in some measure at least to warping may amount to as much as 50-100 ft.

c. In some cases the outer (coastal) margin of the terraces may be as much as 150-200 ft. higher than the inland portion of the surface. The effect is a regular concavity due to warping (Blyth River).

d. The strata forming the surface-cover of the fragments of marine terraces may have a pronounced tilt away from the shore. In one case at least (south bank of the Waiau-ua River) they show considerable disturbance.

e. The most recent movement in the neighbourhood of Cook Strait is known to have been differential, and to have been accompanied by severe earthquake. In Cloudy Bay there seems to be a sharp line of division between a coast showing evidence suggesting recent uplift and one which is known definitely to have subsided in 1855. This, however, may be a localized movement resulting from local crustal instability and not affecting materially the question of a more general emergence of a recent coastal plain. As to whether the Marlborough Sounds area is a "downthrown block" in the sense that it has not participated to any extent in the general emergence, the writer has no knowledge. Hutton (1900, p. 177) remarks that an elevation of 500 ft. would restore the land-connection between the North and the South Island. Banks Peninsula shows a similar drowned topography, and while there is evidence that it was once much higher than now, it has more recently been submerged to a depth much below its present level.

The writer inclines to the belief of Henderson (*loc. cit.*) that any differential movements between adjacent earth-blocks are small as compared with the widespread emergence. It would seem to be a matter of considerable importance to distinguish between the great block-displacements belonging to the older mountain-building movements (Kaikoura), and any feebler continuation of these into a more recent period of general emergence of the land. The application of the eustatic hypothesis in explanation of shift of sea-level amounting to, say, 300 ft. to 500 ft. has its obvious limitations. Also the correlation of oscillations of sea-level with advance and retreat of glacier-ice has never been attempted in New Zealand, though the idea that the initiation of the glaciation was associated with higher land than now has found frequent expression in our literature. The general conception seems to have been that altitude was a controlling factor (Hutton, 1900, pp. 173-8; Marshall, 1912, p. 50), and that the land-level sank under the load of the ice, this being a factor in its retreat. That an isostatic response to unloading on the melting of the ice has been a contributing cause of subsequent elevation of the land has only, so far as the writer is aware, been mentioned by Speight (1926C, p. 56) and it seems quite possible that this may offer an adequate explanation of the entrenchment of some of our rivers in the glaciated floors of their valleys.

The present writer cannot imagine that any simple eustatic hypothesis is adequate to explain a series of terraces ranging between sea-level and 1,000 ft., even though the series be continuous over some hundreds of miles of coast-line. If, however, this complete series be shown to be of world-wide distribution, then some eustatic explanation must be sought; but if it is found that it is restricted to certain latitudes subjected to Pleistocene glaciation, then some measure of explanation may be found in isostatic adjustment to advance and retreat of ice-sheet (combined with the obvious effects of ice accumulation on the level of the sea itself), or in some regional deformation of the earth, the extent of which shows a more or less regular variation with latitude. It would appear that little advance towards solution of the problems presented may now be made, until the zealous exponent of the eustatic hypothesis will admit the capacity of diastrophism as at least a contributing factor.

With regard to the lowest (Recent) platform there is more definite evidence available locally. Daly, the author of the most comprehensive modern exposition of the eustatic theory (1915, pp. 158-251) discusses also the significance of this Recent platform in many parts of the world (1920, pp. 246-61). W. B. Bright, however, points out (1920, pp. 382-4) that the lowest platform of the British Isles, elevated in late Neolithic time, has suffered considerable deformation due to warping. Such irregularity of uplift seems to be characteristic of the platform on the north-east coast of the South Island, there being considerable areas from which it is entirely absent and in which the shore-line is receding rapidly. The rocks exposed to wave-attack, however, show such a variation in hardness that caution is necessary in interpretation of the discontinuity of the platforms, but nevertheless there is sufficient evidence to show that while some parts of the coast have emerged, closely adjacent areas have experienced slight depression. The matter is rendered more complex by the difficulty of determining the extent to which the recent strand-plains of this coast have arisen from progradation. Cotton (1914A), discusses progradation as the major cause of the strand-plain which extends for some 40 miles north of the Clarence River, though there can be little doubt that this area experienced some uplift in harmony with the movement which exposed the rock-platforms and raised the floors of the caves in Halfmoon Bay a little to the south. While uplift in the latter locality may be conservatively estimated at 10-15 ft. above high-water mark, it is according to Cotton, only 6-8 ft. above mean sea-level at the mouth of the Flaxbourne River. With regard to many parts of the coast, however, the present writer has exercised caution in inferring any appreciable uplift at all, where the features of the strand may be explained as arising from other causes.

The wide plain near Amberley probably owes its existence to uplift, the effect of which has been accentuated by progradation, whereas the neighbouring Motunau coast shows definite evidence of slight subsidence, with rapid recession of the shore-line. Taken by itself this Recent discontinuous strand-plain seems to lend no support to the eustatic theory, but its occurrence in many localities in both islands of New Zealand is a very remarkable feature suggesting

more or less uniform withdrawal of the sea. The writer would expect, however, that uneven elevation due to warping is a fairly general characteristic of it.

H. RELATION OF THE EMERGENCE TO THE KAIKOURA OROGENY.

Cotton (1913B, 1914A, 1914B) elaborates the views of McKay (1886, 1890A, 1890B, 1892) regarding the orogoney of Eastern Marlborough, views which have received the support of Thomson (1917, 1919), but which have been challenged by Park (1921). These views have been accepted by Speight and have been applied by him in explanation of the major physiographical features of North Canterbury (1915, 1926A). The question has been summarized by Benson (1921), who assigns the orogeny to the Pleistocene.

The writer has seen nothing in the course of his field-work in this area to lead to any material disagreement with the opinion of Thomson (1919, p. 295) as to the general sequence of the later Tertiary and post-Tertiary movements. These may be summarized briefly as follows: A sea-advance was accompanied by deposition of the Awatere beds (chiefly sandy marls), and this was followed by a slight general elevation. Then came the main Kaikoura orogenic movements by which the parallel chains of the Kaikouras were made, and this was succeeded by a lesser regional uplift (in which a suite of terraces emerged from the sea).

These terraces, however, do not appear to have arisen simply as the result of further upward movement in renewal of the Kaikoura orogeny, and there may be no direct causal connection between them. While the heights of the terraces are more or less uniform over a considerable length of coast-line, the effects of the major orogeny may also be more or less uniform throughout the area, for it has not yet been shown that the extent of the block-faulting diminishes to the southward. Cotton's statements regarding the origin of the Kaikoura Mountains require that vertical displacement due to faulting should amount to 10,000 ft. or more. If similar features in North Canterbury are to be explained in like manner, the amount of displacement cannot be very much less than this. It is to be inferred that the maximum elevation of the land was attained at the culmination of the Kaikoura orogenic movements, but these appear to have been succeeded by a long period of erosion and subsidence. The lower members, at least, of the suite of marine terraces result from re-emergence. According to Henderson (1924) there has been oscillation of sea-level, and it may be suggested here that the alternation of layers of vegetable material, and marine and terrestial gravels, sands and silts, revealed by deep-well boring near Christchurch (Speight, 1911A, plates 9-14) may result from this.

As has been noted above, Cotton (1916B) supposed the post-Kaikoura movements to be "of the mysterious purely vertical kind which appear to have no connexion with compression." He states further (p. 319), "There is evidence of a long period of rest—during which a cycle of erosion reached an advanced stage—intervening between the two sets of movements." It would seem, therefore, that our coastal terraces have no simple connection with renewal of movement in the field of the Kaikoura orogeny, and that

their close correlation in sequence and height with similar coastal features in such widely separated parts of the world as Southern Europe and South America strengthens this conclusion.

I. CONCLUSION.

The discussion of some of the questions raised in Part 2 of this paper is based on certain hypotheses which may not be true. With regard to the continuity and approximate uniformity of the elevation of the north-east coast, the writer considers there can be little doubt. The remarkable correlation of the sequence and heights of the terraces in almost identical latitudes both in Europe and South America cannot very well be looked upon as a mere coincidence, and in this paper it is accepted as a simple fact. In the discussion of our later Tertiary and post Tertiary stratigraphy, however, the writer has merely set out the situation which would arise from acceptance of the contemporaneity of marine terraces in Europe and New Zealand, and the extension of Depéret's use of marine terraces as criteria for definition and division of the European Pleistocene to New Zealand. Whether they are contemporaneous and whether Depéret's wider correlations in Europe are based on sound geology must be left to future investigation. It has been pointed out that the usual criteria for such division do not exist in New Zealand, and our ideas as to definition of Pleistocene time are not very clear.

With regard to the review of Hutton's opinions as to the origin of the Canterbury Plains, this is merely an attempt to reconcile the idea that they must have emerged in harmony with the rest of the coast (which the writer finds it necessary to accept), with the fact that the existing surface features of the plains denote an alluvial origin. Since the writer has not examined the terraces of the major Canterbury rivers, no comment is made regarding the significance of these.

LIST OF REFERENCES.

The following is a complete list of works referred to in the text:—

BARTRUM, J. A., 1916. High Water Rock Platforms: A Phase of Shore-line Erosion. *Trans. N.Z. Inst.*, vol. 48, pp. 132-134.

BENSON, W. N., 1921. Recent Advances in New Zealand Geology. *Rept. 15th Ann. Meeting, A.A.A.S.*, Melbourne, Jan., 1921.

BUCHANAN, J., 1868. Kaikoura District Abstract Rept. on the Progress of the Geol. Surv. during 1866-67. *Rept. Geol. Expl.*, No. 4, pp. 34-41.

BUICK, T. LINDSAY, 1900. *Old Marlborough*, ref. p. 332.

COTTON, C. A., 1913A. The Tuamarina Valley: A Note on the Quaternary History of the Marlborough Sounds District. *Trans. N.Z. Inst.*, vol. 45, pp. 316-322.

—— 1913B. The Physiography of the Middle Clarence Valley New Zealand. *Geol. Journ.*, vol. 42, pp. 225-245.

—— 1914A. A Preliminary Note on the Uplifted East Coast of Marlborough. *Trans. N.Z. Inst.*, vol. 46, pp. 286-294.

—— 1914B. The Relations of the Great Marlborough Conglomerate to the Underlying Formation in the Middle Clarence Valley, New Zealand. *Journ. Geol.*, vol. 22, pp. 346-363.

—— 1916A. Fault Coasts in New Zealand. *Geog. Review*, vol. 1, No. 1, pp. 20-47.

—— 1916B. The Structure and Later Geological History of New Zealand. *Geol. Mag.*, Dec. 6, vol. 111, pp. 243-249; 314-320.

181. —— 1918. River Terraces in New Zealand. *N.Z. Journ. Sci. and Tech.*, vol. 1, pp. 145-152.

COTTON, C. A., 1922. *The Geomorphology of New Zealand.* (Part 1), 1922.
DALY, R. A., 1915. The Glacial Control Theory of Coral Reefs. *Proc. Amer. Acad. of Arts and Science,* vol. 51, No. 4, pp. 158-251.
—— 1920. A Recent World-wide Sinking of Ocean-level. *Geol. Mag.,* vol. 57, pp. 246-261.
DARWIN, CHARLES. Geological Observations on South America.
DEPÉRET CHARLES, 1918-1920. Essai de coordination chronologique generale des temps Quaternaires. *Compt. Rend. Acad. Sci.,* Paris, 1918. Tome 166, pp. 480-6; 636-41; 884-8; Tome 167, pp. 418-22; pp. 979-84; 1919, Tome 168, pp. 868-73; 1920, Tome 170, pp. 159-63; Tome 171, pp. 212-8.
—— 1921. La Classification du Quaternaire et sa correlation avec les Niveaux Prehistoriques. *Compt. Rend. Geol. Soc. de France,* No. 9, pp. 125-127.
HAAST, J. VON, 1864. *Report on the Formation of the Canterbury Plains.* Canterbury Provincial Report, 1864, pp. 1-63.
—— 1871. On the Geology of the Amuri District, in the Provinces of Nelson and Marlborough. *Rep. Geol. Expl. during* 1870-1, pp. 25-46.
—— 1897. *Geology of Canterbury and Westland.*
HENDERSON, J., 1918. Notes on the Geology of the Cheviot District. *N.Z. Journ. Sci. and Tech.,* vol. 1, No. 3, pp. 171-174.
—— 1922. The Chertsey Oil-bore. *Ann. Rept. N.Z. Geol. Surv.,* No. 16C-2c.
—— 1924 The Post Tertiary History of New Zealand. *Trans. N.Z. Inst.,* vol. 55, pp. 580-599.
HUTTON, F. W., 1877. Report on the Geology of the North East Portion of the South Island of New Zealand, from Cook Strait to the Rakaia. *Rep. Geol. Expl. during* 1873-74, No. 8, pp. 27-58.
—— 1884. On the Lower Gorge of the Waimakariri. *Trans. N.Z. Inst.,* vol. 16, pp. 449-454.
—— 1900. The Geological History of New Zealand. *Trans. N.Z. Inst.,* vol. 32, pp. 159-183.
—— 1905. The Formation of the Canterbury Plains. *Trans. N.Z. Inst.,* vol. 37, pp. 465-472.
JOBBERNS, G., 1926. Raised Beaches in the Teviotdale District, North Canterbury. *Trans. N.Z. Inst.,* vol. 56, pp. 225-226.
—— 1927. The Canterbury Plains. Their Origin and Structure. *Natural History of Canterbury,* 1927, pp. 88-96.
KRIGE, A. V., 1927. An Examination of the Tertiary and Quaternary Changes of Sea-level in South Africa *Ann. Univ. Stellenbosch,* vol. 5, Section A, No. 1, p. 81.
LYELL, C., 1868. *Principles of Geology,* 10th Ed., 1868, ref. p. 87.
MARSHALL, P., 1912. New Zealand and Adjacent Islands (in Steinmann's *Handbuch der Regionalen Geologie*).
MCKAY, A., 1877. Report on Cape Campbell District. *Rep. Geol. Expl. during* 1874-76, No. 9, 1877, pp. 185-191.
—— 1881. On the Motunau District, Ashley County. *Rep. Geol. Expl. during* 1879-80, pp. 108-118.
—— 1883. On a Deposit of Moa Bones near Motunau, North Canterbury. *Rep. Geol. Expl. during* 1882, pp. 74-79.
—— 1886. On the Geology of the Eastern Part of Marlborough Provincial District. *Rep. Geol. Expl. during* 1885, pp. 27-136.
—— 1887. On the Grey-marls and Weka Pass Stone in Kaikoura Peninsula and at Amuri Bluff. *Rep. Geol. Expl. during* 1886-87, pp. 74-78.
—— 1890A. On the Geology of Marlborough and the Amuri County of Nelson. *Rep. Geol. Expl. during* 1888-89, pp. 85-185.
—— 1890B. On the Earthquakes of September 1888, in the Amuri and Marlborough Districts of the South Island. *Rep. Geol. Expl.,* No. 20, pp. 1-16.
—— 1892. On the Geology of Marlborough and South East Nelson (Part 2). *Rep. Geol. Expl. during* 1890-91, pp. 1-28.
MORGAN, P. G., 1916A. Notes on a Visit to Marlborough and North Canterbury, with especial Reference to Unconformities post-dating the Amuri Limestone. *10th Ann. Rept. N.Z. Geol. Surv.,* No. 10, C.-2b., pp. 17-29.

Morgan, P. G., 1916B. Soft Limestone Deposits of Cape Campbell, Ward, and Waikari Districts. *10th Ann. Rept. N.Z. Geol. Surv.*, No. 10, C.-2b, pp. 15-17.
—— 1919. The Limestone and Phosphate Resources of New Zealand, Part 1—Limestone. *Bull. Geol. Surv. N.Z.*, No. 22 (New Series), pp. 1-316.
—— 1926. The Definition, Classification, and Nomenclature of the Quaternary Period, with Special Reference to New Zealand. *N.Z. Journ. Sci. and Tech.*, vol. 8, No. 5, pp. 273-282.
Osborn, H. F. and Reeds, C. R., 1922. Old and New Standards of Pleistocene Division in Relation to the Prehistory of Man in Europe. *Bull. Geol. Soc. of America.*, vol. 33, pp. 411-490.
Park, J., 1910. *The Geology of New Zealand.*
—— 1911. Some Notes on the Marlborough Coastal Moraines and Waiau Glacial Valley. *Trans. N.Z. Inst.*, vol. 43, pp. 520-4.
—— 1921. The Geological History of Eastern Marlborough. *Trans. N.Z. Inst.*, vol. 53, pp. 65-72.
Speight, R., 1908. Terrace Development of the Canterbury Rivers. *Trans. N.Z. Inst.*, vol. 40, pp. 16-43.
—— 1911A. A Preliminary Account of the Christchurch Artesian Area. *Trans. N. Z. Inst.*, vol. 43, pp. 420-436.
—— 1911B. The Post Glacial Climate of Canterbury. *Trans. N.Z. Inst.*, vol. 43, pp. 408-420.
—— 1912. A Preliminary Account of the Lower Waipara Gorge. *Trans. N.Z. Inst.*, vol. 44, pp. 221-233.
—— 1915. Intermontane Basins of Canterbury—Part 1. *Trans. N.Z. Inst.*, vol. 47, pp. 336-353.
—— 1917A. The Geology of Banks Peninsula. *Trans. N.Z. Inst.*, vol. 49, pp. 365-392.
—— 1917B. An Ancient Buried Forest Near Riccarton: Its Bearing on the Mode of Formation of the Canterbury Plains. *Trans. N.Z. Inst.*, vol. 49, pp. 361-364.
—— 1918. Structural and Glacial Features of the Hurunui Valley. *Trans. N.Z. Inst.*, vol. 50, pp. 93-105.
—— 1919. The Older Gravels of North Canterbury. *Trans. N.Z. Inst.*, vol. 51, pp. 269-281.
—— 1926A. Intermontane Basins of Canterbury—Part 2. *Trans. N.Z. Inst.*, vol. 56, pp. 355-360.
—— 1926B. Results given by Wells at Christchurch Pumping Station, Beckenham. *Trans. N.Z. Inst.*, vol. 56, pp. 363-368.
—— 1926C. Varved Glacial Silts from the Rakaia Valley. *Rec. Cant. Mus.* vol. 3, pt. 1, pp. 55-81.
Speight, R. and Jobberns, G., 1928. A Definite Break in the Tertiary Sequence in North Canterbury. *Trans. N.Z. Inst.*, vol. 59, pp. 213-231.
Speight, R., and Wild, L. J., 1918. The Stratigraphical Relationship of the Weka Pass Stone and the Amuri Limestone. *Trans. N.Z. Inst.*, vol. 50, pp. 65-93.
Suess, E., 1906. *Das Antlitz der Erde*, Sollas's translation, vol. 2.
Thomson, J. A., 1912. Field Work in East Marlborough and North Canterbury. *Sixth Ann. Rept. N.Z. Geol. Surv.*, C.-9, pp. 7-9.
—— 1916. On Stage Names Applicable to the Division of the Tertiary in New Zealand. *Trans. N.Z. Inst.*, vol. 48, pp. 28-40.
—— 1917. Diastrophic and Other Considerations in Classification and Correlation, and the Existence of Minor Diastrophic Districts in the Notocene. *Trans. N.Z. Inst.*, vol. 49, pp. 397-413.
—— 1919. The Geology of the Middle Clarance and Ure Valleys, East Marlborough, New Zealand. *Trans. N.Z. Inst.*, vol. 52, pp. 289-349.
—— 1920. The Notocene Geology of the Middle Waipara and Weka Pass District, North Canterbury, New Zealand. *Trans. N.Z. Inst.*, vol. 52, pp. 322-415.
Wild, L. J., 1915. Notes on the Soils of the Wairau Plain, Marlboraugh. *Trans. N.Z. Inst.*, vol. 47, pp. 413-16.
Wright, W. B., 1920. Recent Sinking of Ocean Level. Letter to Editor, *Geol. Mag.*, vol. 57, pp. 382-4.

The Volcanic Deposits of Scinde Island. With Special Reference to the Pumice Bodies called Chalazoidites.

By J. ALLAN BERRY, M.S., F.R.C.S.(Ed.).

[*Read before the Hawke's Bay Philosophical Society, 20th August, 1926; received by Editor, 16th April, 1928; issued separately, 23rd November, 1928.*]

PLATES 68, 69, 70.

SCINDE ISLAND is situated on the East Coast of the North Island of New Zealand, and has a large part of the residential section of the town of Napier built upon its hills. The island is an irregular ellipse in shape, its longest axis measuring about 1.85 miles and running almost in a north-eastern and south-western direction. Its widest part, situated close to the north-eastern extremity, measures about three-quarters of a mile. At this extremity it reaches its greatest height of 330 ft. above sea level. Running through the length of the island is a central watershed from which valleys descend on either side. In many places it is bordered by cliffs, and there are numerous quarries and cuttings which facilitate a study of its complicated geology. Although still called an island it is now in reality a peninsula, since within recent times plains have formed between it and the mainland. These plains are largely due to the deposits of silt and shingle brought down by the Tukituki, Ngaruroro, and Tutaekuri rivers. The island mainly consists of highly-fossiliferous limestones which may provisionally be regarded as of Mid-Pliocene age. At some time during this period or later it was raised above sea-level, and during late Pliocene or early Pleistocene times was subjected to extensive denudation, when it obtained very much its present contour. Deposited unconformably on these limestones are pumiceous clays and beds of pure volcanic ash.

The volcanic deposits in Scinde Island may be classified as follows:—

(1) Mid-Pliocene
(2) Pleistocene
  (a) Pumiceous clays and beds of volcanic ash of subaqueous deposition
  (b) Pumiceous clays and beds of volcanic ash of subaerial deposition
(3) Recent.

1.—MID-PLIOCENE.

Layers of pumice were stated by McKay (1) to be interbedded with the limestones in the cliff known as the Bluff. This was denied by Hill (2). There is no doubt, however, that McKay is correct. About 30 ft. above the level of the road close to the breakwater is a stratum extending for some distance of pure pumiceous material.

It is about a foot in thickness; in its lower part it is of coarse texture, and in its upper part it is extremely fine. Microscopical examination demonstrates that the great bulk consists of rounded quartz grains—showing that it had been well washed about by the sea—and that volcanic glass and possibly magnetite are present. Other and more extensive but inaccessible beds are almost certainly of the same nature.

Yet other beds of pure pumiceous material, according to Mr. Hill, were encountered in the "blue clay" which underlies Scinde Island during the course of an experimental boring for oil put down close to the breakwater, and this is in agreement with the fact that beds of pumice are found in corresponding deposits in the country adjoining Napier (3).

2.—Pleistocene.

Resting unconformably on the Napier limestones are pumiceous clays interbedded with layers of pure volcanic ash.

(A) *Beds of Sub-Aqueous Origin.* For the formation of these beds it is necessary to assume that after the island had been elevated above sea-level and the limestones denuded it was once more sub-

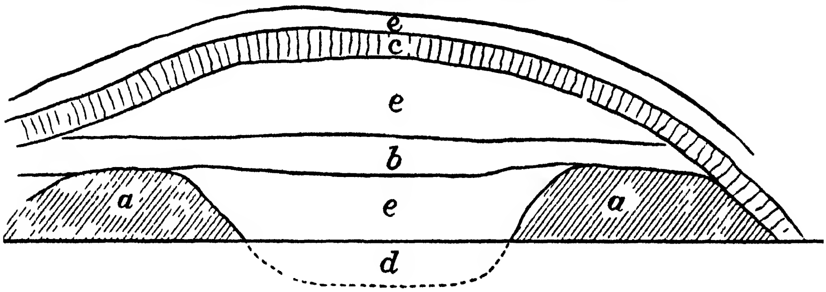


Fig. 1

a = Lower Napier limestones.
b = Pumice deposit of sub-aqueous deposition.
c = Pumice deposit of sub-aerial deposition.
d = Pumiceous clay containing greywacke pebbles.
e = Pumiceous clays.

merged and formed the floor of an almost currentless freshwater lake. Another but less likely possibility is that these beds represent an estuarine deposit. Fig. 1 is a diagramatic section of the cliffs on the south-eastern aspect of the island facing Hyderabad Road, including the brickyards of Morse & Robertson. Here there is a pocket of pumiceous material between 70 and 80 ft. in thickness. This is the deepest section that has yet been exposed, and probably the deepest that exists.

The lowest layer of clay extends about twelve feet below the level of the present floor of the quarry, and contains a stratum of waterworn greywacke pebbles. Similar pebbles are found in a few other localities in Scinde Island, as in Northe's quarry at the end of Faraday Street, where they occur in an unusual whitish clay; in Battery Point, and in Burns Road quarries. At Park Island, the

nearest point on the old mainland to Scinde Island, the same stratum is present. To the left of the roadway leading to Quarantine Island near Petane there is a hillock with a considerable stratum of pebbles interbedded with the pumiceous clays. This particular deposit appears to be of great importance since it probably represents part of the vast deposits of pumice which alternate with the shingles, clays, and lignite-beds, the typical section of which appears in the cliffs forming the southern shore of Hawke Bay, and which Mr. Hill has called the Kidnappers section. This remarkable deposit is found over a great extent of country, and was brought about mainly by the action of fresh water. At Redcliffe, near Taradale and 6 miles from Napier, this deposit has pumiceous clays and volcanic ash, both of sub-aerial origin, resting unconformably upon it. Mr. Hill regards the Kidnapper section as of Pliocene age. It is certainly younger than the Napier limestones and may be classified as belonging most likely to the later Pliocene or to early Pleistocene times.

Above this layer of pumiceous clay with its greywacke pebbles is another layer of a chocolate-brown colour containing much organic matter—a point of some commercial importance since it is found that in the manufacture of bricks much less fuel is needed for material obtained from this layer than for that from other layers. On extracting with ether an oil was obtained, but its properties have not been determined. It seems most likely to be of vegetable origin.

The next layer of interest above this is about 4 or 5 ft. in thickness. In its upper part there are a large number of dark globular bodies, which in the lower part of the layer are larger and more irregular, and are known to the quarrymen as "ironstone." The surface of the small ones is often mammilated, and there is evidence of concentric lamination. These bodies also occur in the cliff above Sea View Terrace, in Havelock Road, and also at Park Island.

The next succeeding layer to be considered consists almost entirely of pure volcanic ash. It is deeper in the middle of the "pocket" than at the sides, and averages about 10 feet in thickness. The lowest part consists of coarse rounded quartz grains, but the upper part is very much finer in texture, the appearance suggesting a sedimentary origin. Microscopical examination shows it to consist almost entirely of angular fragments of quartz and felspar and glass laths. The rounded quartz grains show that some of the material was sorted under water, but the presence of long thin laths of glass show that a certain amount of the material was not transported any distance. The deposit may have been due to pumice falling into fairly calm water, such as a lake, into which some sand was being brought; but the material is not what one would expect from a purely river-borne deposit. This same deposit occurs on the western side of Griffin's quarry, and in the valley attains a maximum thickness of between 20 and 30 ft.

Various other beds of clay having different colours, textures, and properties for brickmaking occur before reaching the beds that are definitely of sub-aerial formation. It seems certain that the beds already described at one time formed a continuous sheet over the whole district, but that as a result of denudation only certain portions of them remain in Scinde Island.

(B) *Beds of Sub-Aerial Origin.* These beds are present all over the island and accurately follow its contour. They are deeper in the valleys than on the hilltops, and although this would be expected from their method of formation it could not be definitely established that they were thicker on certain aspects than on others. This is perhaps explained by the fact that denudation was in progress during the relatively slow formation. They are stratified, and towards their upper part are the layers of volcanic ash which it is proposed to describe later in some detail. These volcanic ash-layers, averaging about 3 ft. 6 in. in depth, are sharply demarcated from the underlying clays, but above merge into the two or three feet of fine light-coloured clay below the surface-soil layer. There can be no doubt that all these clays were originally pumice which has undergone decomposition. Why certain interbedded layers present volcanic material relatively fresh as compared with that of other layers is probably largely explained by a varying rate of deposition. Assuming that the materials forming the pumiceous clays were deposited at a relatively slow rate they would be subjected to weathering conditions which would result in their mechanical disintegration and decomposition, while if the layers of pure volcanic ash were deposited much more rapidly they would not have been subjected to the same extent to such influences. It is also possible that the clays themselves have been derived from pumice having a slightly different chemical nature which would render them more liable to decomposition, or perhaps they are wind-borne from a much older deposit of volcanic ejectamenta in the surrounding country. The fact that the upper layers of pure volcanic ash merge gradually into a clay somewhat similar to some of the subjacent clays, and that interbedded with the volcanic layers themselves are pumiceous clays, is perhaps evidence that the change has taken place *in situ*, although, of course, these interbedded clays may also be derived from older deposits during a period of volcanic intermission. The appearance of the formation is, however, rather against this. Moa-bones have been found in these clays, so that it is reasonably certain that their formation was a somewhat slow process. Probably a great deal of the clays in the North Island have their origin in decomposed pumice. Jameson (4), in dealing with the Auckland clays, regards them as being formed from rhyolitic pumice brought down by the Waikato river from its upper reaches. Hill suggests that the "blue clays," or more correctly blue argillaceous sandstones, are themselves simply volcanic ejectamenta that have been altered by aqueous influences.

3.—Recent.

This is represented by the surface soil which, in an article on volcanic dust-showers in Napier (5), Mr. Henry Hill showed to consist largely of material of volcanic origin. At a later date (6) he recorded a volcanic dust-shower in Napier on the night of 14th December and early in the morning of 15th December, 1896. The wind had been blowing from the north-west while an eruption of Mount Tongariro was in progress. The dust that fell was of a light-grey colour, and as Mr. Hill pointed out the shower bore full testimony to the truth of his statement that "in and around Napier a large percentage,

in fact the larger portion of the soil is of volcanic origin.'' Subsequent analyses have amply confirmed this.

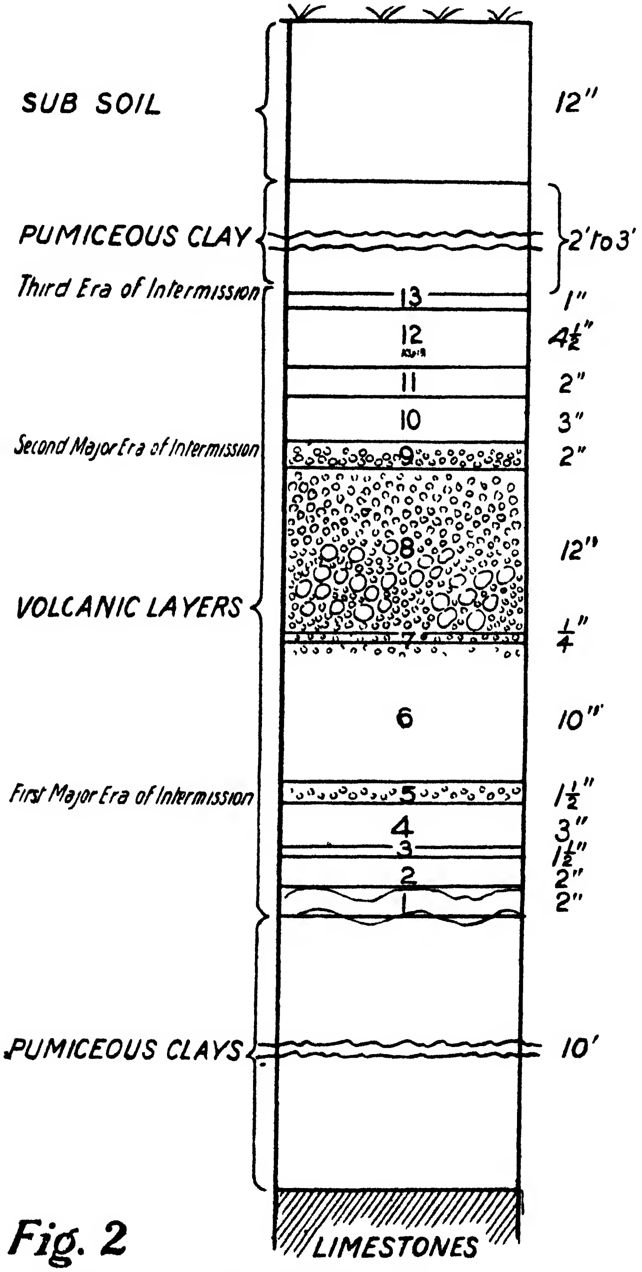


Fig. 2

VOLCANIC BEDS OF SUB-AERIAL ORIGIN.

The thickness of these beds varies with the amount of denudation that their upper layers have undergone prior to the deposition of the overlying stratum of pumiceous clay. Measurements from the base of

the volcanic deposit to the lower border of layer 8, the chalazoiditic layer, both clearly defined points and representing a thickness from the uniformity and constancy of the intervening layers that has probably not been appreciably altered by denudation, were made in a large number of places on the island. From these it was clear that the deposits are certainly thicker in the valleys than on the hilltops, and probably thicker on the northern and western than on the southern and eastern aspects. The following is the most constant order in which the layers are deposited, and is applicable also to those areas that have been examined on the mainland within a short distance of Scinde Island. (See Fig. 2).

(1) The lowest, a most constant characteristic layer, is one to which Mr. Hill was undoubtedly referring when he described the pumice as being "finer than the finest flour and as white as snow." This layer is about 2 ins. in thickness. It rests on an uneven surface of brown pumiceous clay, and in consequence often has a sinuous outline. This layer contains little if any magnetite.

(2) A layer of about equal thickness, greyish in colour, and composed of particles which are rather coarser than in the preceding layer.

(3) A layer stained red or brownish by iron oxides, about ½ in. in thickness, is very constant. In some places where the deposits are thick this layer may be double and separated by the greyish material of layer 2.

(4) A layer of about 3 in. in thickness, coarser in texture than the preceding layers, and becoming coarser in its upper part, often apparently forming two different strata. This layer contains fragments of pumice sometimes about a quarter of an inch in thickness.

(5) A well-defined brown layer of about 1½ ins. in thickness which is relatively resistant to denudation and is the lowest layer in which sparse small chalazoidites are present.

(6) A layer about 10 in. in thickness containing larger pieces of pumice than any of the others. The largest are in the upper part of the layer, one fragment in the dry state being over 900 mg. in weight. These pumice fragments are irregular in shape and their angles are smooth and rounded. The upper part of this layer contains chalazoidites intermingled with the pumice fragments.

(7) A layer stained a reddish colour due probably to limonite, which is not very constant, and when present averages about a quarter of an inch in thickness. Sometimes it is very well marked, as in the cutting in Napier Terrace, and contains small rather sparsely-scattered chalazoidites.

(8) A layer which, on an average is 12 in. in thickness, in which the chalazoidites are most abundant. The matrix appears the same throughout. It is divisible into two fairly well-defined layers, the lower part con-

taining the largest chalazoidites and the upper part containing smaller ones of a remarkably constant size.

(9) A very tough layer resisting denudation more than the preceding layers, and measuring on an average about 2 in. in thickness. This layer, often divided into two, is also packed in its lower part with small chalazoidites, apparently continuous with the subjacent stratum.

(10) A layer of fine pumice dust averaging about 3 in. in thickness.

(11) A tough red-coloured layer about 2 in. in thickness, similar to layer 9.

(12) A layer of fine pumice dust about 4½ in. in thickness.

(13) A clay layer of about 1 in. thick.

(14) Following on this is a deposit of fine ash which is sometimes traversed by another layer or two of pumiceous clay and merges gradually into a layer of pumiceous clay between 2ft. and 3 ft. in thickness.

Resting on this is the soil-layer.

This order is applicable to all the deposits found in various parts of the island, although from layer 10 onwards they may be absent wholly or in part. On examination of a section exposing these layers, more or less vertical cracks are seen running sometimes from the clay above to the clay below, more often extending through only a few layers. They are probably due to tension during drying and consolidation.

CHALAZOIDITES.

One of the most interesting features of these deposits is the presence of ellipsoidal-shaped bodies composed of pumice varying in size from about a pin's head up to about half an inch across. They have been formed, according to the theory to be stated later, in very much the same manner as a hailstone, and have a similar laminated structure. For this reason I have called the theory of their formation the "hailstone theory," and the bodies "chalazoidites" from the Greek Χαλαζοειδος resembling hail, and λιθος a stone. The term "pisolite" has been used, but is unsatisfactory as it refers to a different structure having a different origin. They have also been called "lapilli" but this, too, is a misnomer. There is a distinct need for a new term and "chalazoidite" seems to have the advantage in accurately describing their suggested method of formation.

Chalazoidites occur in layers 5 to 9, but are present in greatest abundance in layer 8, which is therefore called the chalazoiditic layer. There seems no reason why they should not occur in the other layers, and it is possible they may have been present originally but have suffered disintegration. This appears to have definitely occurred in the upper part of layer 9, which, as will be mentioned later, probably represents an interval of intermission of volcanic activity, when weathering influences would result in their destruction. In some sections, as in Amner's quarry in Milton Road, chalazoidites are found in other layers besides those mentioned; the extraordinary density which characterizes the whole section in this locality may explain their preservation in these layers.

In the chalazoiditic layer itself as a general rule the chalazoidites appear to be diffusely scattered through the dust-matrix; the largest ones are found towards the base, and the smaller ones towards the top, the transition from the large to the small being rather sharply defined. There is evidence that the chalazoidites were not always diffusely scattered through the matrix, but were themselves arranged in layers. This is particularly well seen in sections in the valley through which Burns Road runs where the chalazoiditic layer is well developed, measuring 17 or 18 in. in thickness. Here in the lowest part the chalazoidites are quite small and arranged in several horizontal layers; above this is a stratum where the largest and also the smallest chalazoidites occur, and this in turn is succeeded by the layer of smaller ones of uniform size. In a few other places on the island the same arrangement can be observed, and is probably explained by the fact that this condition is usually found in sheltered valleys where wind action would not affect stratification.

It is probably impossible to determine what was the original relationship of chalazoidites to matrix, as the latter consists to an unknown extent of disintegrated chalazoidites. On passing a large quantity of the upper part of the layer and a similar quantity of the lower of the layer, through a "30 mesh" sieve, i.e., one with 30 holes to the linear or 900 to the square inch (a size which is very effective in the separation), it was found that in the case of the lower sample a little less than half by weight was retained in the sieve, and in the case of the upper sample a little more than half. The residue left in the sieve consisted entirely of chalazoidites, fragmented chalazoidites, "tubules," and small fragments of pumice. It is a very extraordinary fact that the proportion of chalazoidites should be roughly the same whether they were removed from the lowest part of the layer where the largest occur or from the upper part of the layer, where they are almost uniformly of small size. Still further, it appeared in both cases that about one half of what was retained in the sieves consisted of fragmented chalazoidites. It might be expected that the proportion of chalazoidites would differ in different localities for the same particular stratum, such as the chalazoiditic layer. For at least several parts of Scinde Island the proportion appears to be constant. If one or more of the conditions necessary for chalazoiditic formation were absent, then they would be absent, as appears to be the case in places west of Napier.

Appearance: The larger chalazoidites are of a light-grey colour with small dark rectangular patches very similar to those on a bird's egg, and on sectioning, similar black markings are sometimes seen running in the line of the laminae. The smaller chalazoidites are darker in appearance, and the dark areas are not noticeable.

Weight: The heaviest chalazoidite, a very exceptional specimen, found in the western portion of the island, weighed when dry 1,063 mg., and the smallest that appeared definitely to be a chalazoidite weighed 1 mg. If 10 grms. of the lower part of the chalazoiditic layer (the specimens in this case were taken from near Jellicoe Ward at the Napier Hospital) is examined, there will be found on the average one chalazoidite weighing 300 mg., two weighing 200 mg., six weighing 100 mg., and about 40 weighing 35 mg., the remainder,

including a large number of fragmented specimens, would average 15 mg. If 10 grammes of the upper part of the chalazoiditic layer is examined it will be found that the chalazoidites are much more uniform in size, the average weight being about 15 mg. Fig. 3 illustrates graphs showing the numbers of intact chalazoidites of certain weights differing successively by 5 mgs., present in an equal mass first from the lower (broken graph-line), and then from the upper part of the layer (solid line). The solid graph-line shows that the largest number of chalazoidites in the upper part of the layer weigh 15 mg., and none in this particular sample was found weighing more than 35 mg. The broken graph-line shows that here, too, the greatest number of chalazoidites weight 15 mgs. There was no evidence that the smaller chalazoidites were derived to any appreci-

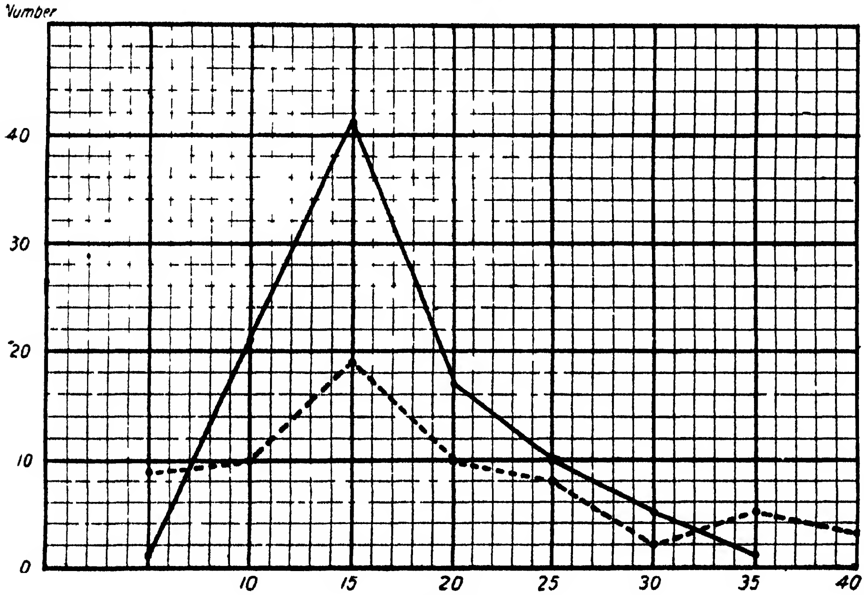


Fig. 3

able extent from the larger chalazoidites owing to exfoliation of the capsular layers, nor was there any evidence that the larger chalazoidites were built up by accretion from the smaller ones.

Shape: A large number of chalazoidites of varying sizes were measured, and it was found that they are all ellipsoids having varying eccentricities with no constant relationship between them. Some are almost perfect spheres, while others are shaped very much like a grain of wheat. During descent they probably tended to be spherical and were saturated in varying degrees with water, which would render them plastic. The impact on striking the ground, if it were an even surface, would tend to flatten them out, and it is noticeable when some of the larger flattened specimens are examined *in situ*, that the short axes are perpendicular to the plane of the stratum, although this is by no means a constant feature. In some cases small dents or depressions can be made out, almost certainly due to the fact that in their fall, instead of striking the soft pumice

matrix, the chalazoidites came into contact with others that had already fallen, or in their turn were struck by others falling later. The weight of the materials deposited above the chalazoidites might also be a slight factor in causing the flattening, but it seems more probable that in order to remain unbroken they must have been at least only moderately saturated, and therefore only moderately plastic. If they had been saturated in excess they would have undergone destruction immediately on striking the ground. There is no evidence that this was not the fate of some of them, nor is there any evidence as to the length of time involved in the formation of the layers themselves, although in all probability it was extremely rapid, and weight might therefore cause slight flattening of the chalazoidites after deposition, and before drying out or setting took place. Fig. 6 shows chalazoidites which have been flattened on one aspect, due apparently to the impact on striking the ground. This shows definitely that they must have been in a plastic state. In these cases of a definite flattening on one aspect, it is noticeable that this is at one pole of the longest axis, showing that they fell with the long axis vertical, and probably had a spinning motion on this axis. The appearances suggest that there was no violent wind at the time of their deposition, and that they fell vertically. If, in the process of setting, there was contraction, then the tendency of a spherical body to assume a tetrahedral shape might also be invoked as an explanation for some of the irregularities. The fact that chalazoidites show considerable variations in the ratio of the short axes to the long axes, and the presence or absence of dents, is largely explained by the different degrees of saturation resulting in different degrees of plasticity, whilst in many instances the irregularities are due to exfoliation of the outer capsular layers. Still one other irregularity particularly well marked with the larger chalazoidites is the presence of a small "tail" of what appears to be adherent matrix, which can in most cases easily be removed from the capsule by a little pressure. It is in all cases quite distinct from the outer layer. This may be analogous to the "tail" of a falling drop of water, but the comparatively loose attachment is very suggestive that it was formed secondarily. The more probable explanation is that the water in the plastic chalazoidite on reaching the ground would, by capillarity, collect at the lower pole, and owing to the chemicals in solution would cause to adhere a portion of the adjoining matrix, thus forming a "tail." A stained section through a chalazoidite (see Fig. 7) sometimes shows a meniscus where the stain is more intense, suggesting that there has been water which has caused slight chemical alterations. If a chalazoidite is cut across and part of the cut surface is placed in contact with a dye the fluid is absorbed and forms a meniscus with the convexity upwards, which is explainable by surface tension and the greater porosity of the central nucleus. The appearance is very similar to that seen in the stained specimens. Why it is not seen more often probably depends on the manner of the section, and it is also possible that it may be due to water that has entered the chalazoidite long after its formation. An examination *in situ* to determine on which aspect the "tail" was situated was, as might have been expected, unsatisfactory.

Density: No exact measurements were made to determine the hardness of specimens of different sizes in the dry and in the wet state. Most of them are considerably denser than those mentioned by Pratt (7) as occurring at Mount Maquiling in the Philippines, which could be " broken only with difficulty between the fingers." Some of the larger ones were able to withstand a pressure of well over 100 lb. without fracturing. In the saturated condition they will not stand so much pressure, but show no evidence of deformation before fracturing occurs.

Effects of Heat: On moderate heating the chalazoidites become somewhat dark in colour. This appearance is due to organic material that has entered into their composition secondarily. If the eruption were intermittent it is likely enough that a slight vegetation of lichens and mosses sprang up similar to that which occasionally grows on exposed sections at present. The decomposition of this vegetable matter would account for the organic material, although it seems more likely that it has entered at a later date from the period of intermission represented by the superjacent clay stratum. At a temperature of about 800° C. the outer layers become partially vitrified, but a temperature of above 1,000° C. was needed to ensure complete vitrification.

Resistance to Disintegration: One of the most extraordinary features of the chalazoidites is their resistance to disintegration. For their preservation it seems necessary that they should fall on soft ground, otherwise they would be broken in pieces or deformed out of all recognition. Before and after drying, certain chemical changes must have occurred cementing them into a solid mass. What exactly these changes are it is difficult to state. It has been pointed out (8) that 0.150% $Si\ O_2$ is dissolved from fine tuff after standing in a vessel for six weeks. From this it might be assumed that the silica was reprecipitated and cemented the chalazoidite together.

Something similar is described by Hewitt (9) in the cliffs northwest of Arapuni along the northern side of the Waitete Valley. These cliffs are composed of pumiceous breccia, and there has developed a hard outer skin up to 2 in. in thickness due to the deposition of silica. The same explanation may be used for the density of the layers which represent periods of intermission. The more or less vertical cracks in these volcanic layers are often bounded on each side by similar dense layers.

That there have been chemical changes since the formation of the chalazoidite admits of no doubt. At one time it must have been plastic, but no amount of saturation at present will reproduce that condition. The larger and medium-sized chalazoidites are particularly resistant, but the smaller ones are not so resistant. This is probably due to the fact that in the smaller chalazoidites their surface area in relation to their mass is relatively greater than in the larger chalazoidites, and also, as will be mentioned later, their porosity is greater. Their ellipsoidal shape would also help them to withstand pressure. The nature of the matrix in which the chalazoidites are imbedded is also of importance. When the matrix is soft, as it usually is, evidence of disintegration is shown by the large number of fragmented specimens present on sieving. When it is of the

peculiar density seen in Amner's quarry disintegration appears to have been absent or almost negligible. There would appear to be two methods of disintegration. In the case of the larger chalazoidites exfoliation of the capsule seems to be the commoner method; in the case of the smaller chalazoidites, complete fracturing. Pratt (7), in discussing this question in relation to the chalazoidites that occur in the Philippine Islands, states, "It would appear equally remarkable that they should retain their form upon falling into water. Yet it is beyond question that the tuff series into which the wells at Banan and Taal penetrated is in great part water laid, and it is to be presumed that the mud balls encountered in the wells at these towns fell into the sea originally." It would be expected that deep borings on the plains round about Napier would also show the presence of chalazoidites, but up to the present they have not been noticed, probably because they have not been looked for. In a section of these volcanic layers a whitish efflorescence appears which is crystalline and soluble in water. Its exact chemical nature has not been determined, nor what part it plays, if any, in the "rotting" of pumice.

No experiments have been carried out to ascertain the elasticity, the electrical properties, etc., of chalazoidites, but no doubt if these were determined for varying sizes very interesting graphs would be obtained.

Structure: On naked-eye examination of sections it was found that the larger chalazoidites showed, as the result of weathering, slight evidence of a nucleus, which in some cases had apparently fallen out, leaving a cavity; and more rarely that there was a distinct suggestion of concentric lamination. Usually a cut section of a chalazoidite appears perfectly homogeneous, except perhaps for a slightly less dense and more brownish structure in the middle as compared with the outer parts.

In order to determine whether all chalazoidites showed a definitely laminated structure, sections were treated with carbol fuchsin and then thin scrapings removed from the surface. By this method it was found that the dye had penetrated more deeply into the central area or nucleus in rather a punctate manner, and that there were concentric stained laminae separated by other non-stained layers.

On treating intact chalazoidites with Canada balsam and grinding down a thin section, it was found on microscopical examination that the deeply staining nucleus and the absorbent concentric laminae were due to their texture being less dense than the non-staining laminae. The dye was able to penetrate more deeply into the nucleus and stained rings than in the non-staining rings. Other methods of staining, such as treating a section with silver nitrate and then applying formalin, shows the absorbent concentric laminae as very distinct black rings. No satisfactory methods were devised for showing up the laminae by staining-methods in the smaller chalazoidites, but they are undoubtedly present as is shown by those specimens that have been exposed to weathering conditions, and also by the occasional presence of a darkly-stained laminae due to iron oxides. From these various methods of examination it was found

that all chalazoidites have the characteristic structure of a nucleus surrounded by concentric laminae, but there were differences in the size and shape and position of the nucleus, and differences in the number and thickness of the laminae. It was quite clear that the laminae themselves differed somewhat in thickness; in some places a given layer may be absent and its place taken by outer succeeding layers (see Fig. 8).

Radiological examinations were made to ascertain whether these would throw any light on the structure of the chalazoidite. As has already been mentioned, incomplete fractures were occasionally revealed in the apparently intact chalazoidite. Thin sections of from ⅛ in. to 1/16th in. were taken from the thickest part of the largest specimens, and plates taken at varying distances and varying exposures. From these it was found that the nucleus was always less radio-opaque than the outer portions, and there were faint but distinct evidences of laminae in the capsular portion. Very often a very much less radio-opaque nuclear point or nucleolus could be demonstrated. It was small and usually rounded, but sometimes oval and elongated. In Fig. 8 B there are two densely radio-opaque particles, probably quartz, in the nucleolus. Examples of matrix and crushed chalazoidites were X-rayed, and it was found that the proportion of radio-opaque material was greater in the matrix than in the chalazoidite.

Nucleolus or Nuclear Point: This represents the first stage in the formation of a chalazoidite. That it represents an area of much looser texture than the surrounding nucleus is undoubted, both from the microscopical examinations and from the staining reactions, which sometimes show it up as a small intensely-stained area. Whether it has any peculiar chemical composition was not determined.

Nucleus: The nucleus is always eccentric in position, and varies in size with the size of the chalazoidite. No evidence of its ever being double was found, although one might expect this to occur occasionally. Its relation in mass to the outer capsular portions will be discussed later. With the larger specimens the nucleus showed no evidence of lamination.

Capsular Layers: The number and thickness of these layers varies with the size of the chalazoidite. The laminated appearance depends on the varying density of the different layers. A layer of less density absorbs the stains more deeply than the layers which have a greater density. These layers appear to alternate regularly unless one portion of a layer is absent. In sections of the chalazoidites it is rarely found that there are oval air-spaces—lacunae—which run in the line of the laminae. These are more frequent in the outermost layers. These may possibly be due to certain soluble constituents having been leached out, or even due to contained air-bubbles during the formation of the chalazoidite.

Outermost Layer: It is clear that in many cases this layer is of much greater density than any of the other layers; in some specimens the surface can be scratched only with a knife, and this extreme density is suggestive of vitrification.

RELATIONSHIP OF NUCLEUS TO CAPSULAR LAYERS.

From the evidence of structure shown by staining, microscopic enlargement, and radiological treatment, it is clear that the nucleus is of looser texture and has a higher porosity than the outer or capsular portions. In view of this fact an attempt to determine the relationship in mass of the relatively porous portion was made by estimating the total porosity of chalazoidites of varying sizes. Since chalazoidites of the same approximate weights show differences in structure, large numbers of a given weight were taken for each estimation. The method adopted was inexact, but the results shown in Fig. 4 seem to be fairly uniform. By calculation it is clear that the size of the nucleus or more porous part varies but little, whilst that of the capsular layers or less porous part increases rapidly with the increasing size of the chalazoidites. From 5 mg., the lowest limit of weight of chalazoidite used, to about 70 mg., the porosity falls

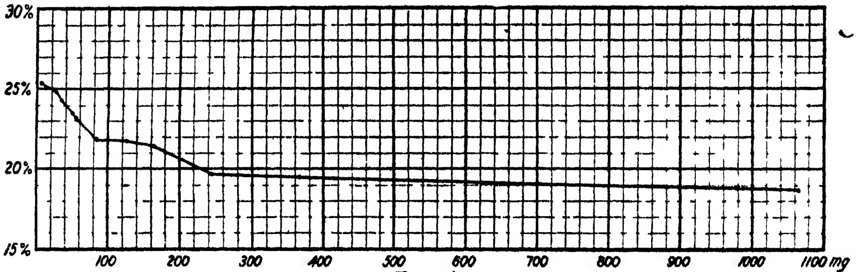


Fig. 4

from 25.3% to 23.25%, which seems to imply that the capsule is increasing very rapidly as compared with the nucleus, and that the masses are comparable. From about 70 mg. onwards the curve becomes more flattened, implying that the mass of the capsular layers now considerably overshadows that of the nuclear portion.

MICROSCOPICAL EXAMINATION.

Mr. L. I. Grange reports as follows: "The constituents are typical of rhyolitic pumice. They consist largely of colourless particles of glass with felspar, quartz, and finer material that was not resolvable." Other minerals such as rutile and limonite are also present. An examination of a large chalazoidite from the banks of the Waikato near Taupo to determine whether there was any difference between the nuclear and capsular portions showed nothing very marked. "Both consist mainly of glass, comminuted pumice, with a few minute grains of felspar and more rarely tiny prisms of a green mineral and minute black specks. The green mineral seems to be either hornblende or a pyroxene, but the crystals are too small to be identified with certainty. I suppose the minute specks of black to be magnetite, as you have demonstrated that mineral. In the outer shell the glass fragments are perhaps ever so slightly finer in grain than in the nucleus, and the shell shows perhaps more of the flocculent almost clay-like patches, which I suppose represent aggregates of the very finest dust particles." (Campbell Smith).

MATRIX OF CHALAZOIDITIC LAYER.

On the hailstone theory it was thought that probably all chalazoidites had their origin at a low and fairly constant level in the pumice-cloud, and that the formation of the larger ones was due to their being carried by vertical air currents into higher levels of the atmosphere where finer volcanic dust predominated, from which they received many of their additional laminae. As seems proved by their porosity and by a study of stained specimens, growth in size depends largely on the increase in the number and thickness of these capsular layers, and not so much on the size of the nucleus. It was reasoned that it was likely that the size of the particles, and therefore possibly the chemical composition of the particles, would vary in the lower part of the matrix as compared with those in the upper part, and still further that the chalazoidites of varying sizes might also show chemical differences. Mr. F. M. Saxton very kindly graded samples from various layers. His report is as follows: "I have numbered the samples submitted as follows:—

No. 1.—No. 1 layer.
No. 2.—No. 2. layer.
No. 3.—No. 6. layer.
No. 4.—Matrix containing small chalazoidites.
No. 5.—Matrix containing large chalazoidites.

Each sample was first dried and then gently powdered between spatula and paper in order to free concreted fine particles without actually grinding them to a finer state than already obtained. No. 2 was in the form of a single large lump; this was easily friable, and after gently breaking was treated as the other samples.

	No. 1	No 2	No. 3	No. 4	No. 5
	%	%	%	%	%
Retained $\frac{1}{4}$-in. mesh sieve	...	...	...	...	2.7
$\frac{1}{8}$,,	...	..	1.0	11.2	26.5
$\frac{1}{10}$,,	..		1.0	12.5	7.2
$\frac{1}{40}$,,	3.0	20 5	41.0	22.4	20.0
$\frac{1}{80}$,,	13.2	35.0	34.5	10.6	10.0
,, $\frac{1}{200}$,,	15.3	14.6	14.5	8.3	5.1
Passing $\frac{1}{200}$,,	68 5	29.2	8.0	34.9	28.5
	100.0	99.3	100.0	99.9	100 0

The total of 99.3% in the case of No. 2 is on account of the very small quantity of material that was available.

No. 4: The 11.2% and 12.5% retained up to 1/10 in. mesh consisted almost entirely of chalazoidites, and about half of the 22.4% retained by the 1/40 in. mesh was mostly of intact chalazoidites, so that the total percentage was 34.9%.

No. 5: The 2.7%, 26.5%, and 7.2% up to 1/10 in. mesh were almost entirely composed of chalazoidites, 25% of the 20% retained in 1/40 in. mesh consisted mostly of intact chalazoidites, so that the total percentage was 41.4%."

It will be noted that the proportions of chalazoidites given in these figures differ from the proportions given previously, where it was found to be roughly one half in each case. The difference is explained by the method of crushing between a spatula and paper. This would destroy a large proportion of the smaller fragmented specimens which are easily friable. From these figures it is clear that the greatest proportion of the finer particles is in the upper layer.

No method was found of determining the sizes of the particles entering into the formation of the chalazoidites. As would be expected with any coloured homogenous substance, crushing would render it lighter in colour; or if fractions were separated by sifting, the finer portions would be lighter in colour than the coarser, merely by reason of their fineness. It was very noticeable that the matrix, on being passed through the sieves of varying sizes, became progressively lighter in colour as it became finer. This might in [illegible] be explained by the differences in chemical composition. On the rough crushing of a number of small chalazoidites and a number of large ones, the mass from the large chalazoidites was much lighter in colour than that from the small. The differences in colouration appear to be largely due to the quantities of magnetite and ferro-magnesium minerals present.

Estimations of the amount of magnetite in the matrix and in the chalazoidites appeared to be of some importance, and attempts to ascertain these were made by means of the electro-magnet. It was found that no accurate estimations were possible, owing to the fact that the magnetite grains were often imbedded in, or adherent to, other substances. In addition, limonite was freely present and this, too, is feebly magnetic. It is stated that as a rule coarse grains of magnetic substances may be more easily removed than fine grains of this material, since fine grains usually have a larger percentage of non-magnetic material adhering to them, and hence a greater magnetic force is necessary to remove them. The result of these examinations showed that much more material was extracted by the electro-magnet from the matrix than from the crushed chalazoidites, and more from the small than the large chalazoidites.

An explanation of these results is difficult. Pumice dust consists of several minerals of specific gravities varying from magnetite 5.18 and rutile 4.2, to quartz 2.65 and felspar 2.58-2.76. It might appear that there had been some gravitative selection whereby the heavier minerals fell more rapidly than the lighter ones, but bodies of equal mass and equal air resistance will fall with the same velocity from the same height. This is true up to a certain stage of subdivision, but even beyond this the differences in the rates of fall would be very slight, possibly not more than 1/1,000th of the distance travelled. Other factors come into the question, such as the height to which the various constituents would be ejected from the volcano, and, most important of all, the effect of wind, which would have a great influence in causing a gravitative selection. It would be expected that a given layer of volcanic dust traced outwards from the centre of eruption could not only show differences in texture, but, from this "gravitative selection" also differences in chemical composition,

the minerals of lighter specific-gravity predominating. Whether this has been proved I am unable to learn, but the question could easily be settled by tracing the chalazoiditic layer, or any other well-defined layer of these beds inland and having analyses made of the material at different points. The material ejected from the Tarawera eruption of 1886 should be very suitable for examinations of this sort. It would be expected that the material which floated in the air for such long periods of time following the Krakatoa eruption was very different in some respects from that which fell near the volcano.

In dealing with the magnetite present in the chalazoidites it must be kept in mind that if the amounts could be accurately estimated they would not necessarily bear any relation to the total iron shown on chemical analyses. Other compounds of iron are relatively easily susceptible to solution processes, while magnetite is extremely resistant. It might happen that in a chalazoidite of a given size 50% of the iron might be in the form of magnetite, and the other 50% in other compounds of iron; in a chalazoidite of another size 80% might be in the form of magnetite and 20% in the other minerals.

TUBULES.

Another structure met with is a tubule of volcanic ash. This is found in nearly all layers. The fact that in some instances these tubules have intimately adherent to them imperfectly formed chalazoidites is very suggestive that they have an aerial origin. Another possibility is that they may have formed round roots of plants that have grown during intervals between the depositions of these layers, but this does not seem likely. It is noticeable, however, that the roots of recent plants that have died in these beds become encased in a rather dense pumiceous envelope. On looking through the literature, nothing very similar to it appears to have been described. The tubules are of varying lengths, shapes, and sizes. A large majority are branched, and many are adherent to imperfectly-formed chalazoidites. They range in length from 1 mm. up to 8 or 9 mm., and in thickness from 1 mm. to 2.5 mm. Occasionally they are much larger. They show no evidence of vitrification. Tubules of ice have been described as falling during hailstorms, but no very satisfactory explanation has been given to account for them. It seems possible that these tubules are analogous in their origin to the ice-tubules, whatever that origin is. In Fig. 6 B 1 and 2 are tubules. On X-ray examination of 1 the central tube was seen to bifurcate towards the right extremity, and at various points along its length were small openings through the wall, indications of which can be detected in the figure.

AERIAL FULGURITES.

Yet other structures that are fairly common in certain localities, as in Havelock Road, are fragments of what at first sight look like silicified wood. These occur most frequently in the chalazoiditic layer, but are found in almost any of the layers. They are from about an inch to a foot or more in length, and from about a quarter

of an inch to an inch or more in thickness. On cross section their central portions show distinct evidence of vitrification, and also a longitudinal tubular structure apparently due to the formation of gases. Very often they are in the form of single large tubes. Imperfectly-formed chalazoidites are often densely adherent to their exterior surface. It seems highly probable that these structures were formed by the electrical discharges that must have accompanied the volcanic eruption and the formation of the chalazoidites. The usual formation of fulgurites is by the electrical discharge entering the ground, so that they are usually more or less vertical in position. It is suggested that these fulgurites may have been formed from fusion of the materials suspended in the air, although it is certainly difficult to visualize such a density of particles as would make a welding of this nature possible. The attitude of these fulgurites is always horizontal, which may be expected from their suggested manner of formation, although it is conceivable that in the loose matrix they would assume this position after formation by the usual method.

Microscopical examination of these fulgurites shows them to have a homogenous appearance with no evidence of any cellular structure.

CHEMISTRY.

Mr. Morgan, late Director of the Geological Survey, kindly had the following analyses made by Mr. F. T. Seelye of the Dominion Laboratory.

No. 1 is an analysis of No. 1 layer.

No. 2 is an analysis of the larger chalazoidites from the lower part of the chalazoiditic layer.

No. 3 is an analysis of the matrix in which they were embedded.

No. 4 is an analysis of the smaller chalazoidites from the upper part of the chalazoiditic layer.

No. 5 is an analysis of the matrix in which they were embedded.

		No. 1	No. 2	No. 3	No. 4	No. 5
		%	%	%	%	%
Silica	SiO_2	72.46	70.78	71 01	70.27	69.72
Alumina	Al_2O_3	12.23	12.14	12.18	12.42	12.47
Ferric Oxide	Fe_2O_3	0.95	1.38	1.38	1.43	1.50
Ferrous Oxide	FeO	0.94	0.85	0.94	0.83	0.94
Magnesia	MgO	0.34	0 56	0.61	0.54	0.63
Lime	CaO	1.54	1.59	1.76	1.51	1.74
Soda	Na_2O	3.65	2.83	2.75	2.87	2.97
Potash	K_2O	3.01	2.74	2.74	2.63	2.54
Loss on ignition ...	...	3.93	4.69	4.43	4 65	4.63
Water lost below	105°C	0.70	2.08	1.94	2.41	2.42
Carbon Dioxide	CO_2	none	none	none	none	none
Titanium Dioxide	TiO_2	0.20	0.23	0.24	0.23	0.24
Manganous Oxide	MnO	0.0	0.04	0.05	0.04	0.05
Sulphur	S.	0.01	0.025	0.04	0.025	0.04
Baryta	BaO	0.08	0.08	0 08	0.08	0.08
		100.10	99.97	100.15	99.94	99.97

In some analyses carried out by Mr. A. E. Aldridge to determine the amounts of silica in chalazoidites of different sizes, he obtained the following interesting figures:—

1.	Chalazoidite weighting 840 mg.	69.76%
1.	Chalazoidites of large size	68.03%
3.	Chalazoidites of small size	67.90%
4.	Chalazoidites of differing weights, 5 mg.	64.68%

These differences in the silica-content may be partly explained by the decomposition that has gone on in the outer layer of the chalazoidites. Assuming that the outer capsular layer were equally thick for the small as for the larger chalazodites, there would be a greater proportionate bulk in the case of the former. In acidic rocks the result would be reduction in the content of silica and slight increase of $Al_2 O_3$, with increase, of course, of water.

Mr. F. T. Seelye, to whom my thanks are due, has very kindly read through this paper, and in a private communication has discussed the problem of the nature of the cementing-substance. "The analyses show that it cannot be a carbonate nor calcium sulphate. It may, of course, be silica or even clay, but whatever it is now the change would seem to have started at the same time as the pumice was formed, or very shortly afterwards, for it seems almost impossible for water alone to render ordinary pumice dust cohesive enough to resist fracture, even if the mass dropped into a bed of pumice dust from a height. As you mention, superheated steam would indeed have a marked effect on the chemical constitution of pumice, and if gelatinous silica could be liberated by such action on the surface of the particles, this might prove a very effective binding material. I have also wondered if the acids and other gases so often evolved at the time of a volcanic eruption should not also be considered as playing a prominent part in modifying the properties of the finest pumice dust. Jaggar possibly has this in mind, as your reference to his paper shows. That large amounts of acid and other active gases are evolved during many eruptions, and especially at the beginning, seems to be generally accepted. Sulphurous gases seem commonly to accompany explosions, whilst hydrochloric acid and chlorine vapours are common, and are especially associated with high temperatures and energetic action. Even dilute hydrochloric acid solution at 100° C. quite appreciably attacks pumice, yielding chlorides of iron, aluminium, etc., and the attack would probably be much more intense at the very high temperatures prevailing during an explosion. In a recent paper E. G. Zies, calling attention to the vapour-phase activity of an igneous body, states that in the 'Valley of Ten Thousand Smokes' in Alaska, approximately a cubic mile of rhyolitic pumice was deposited after having been blown through the old floor of the volley. Many fumaroles are located in the pumiceous area. The persistence of relatively high temperatures (97° C. — 650° C.), and great volumes of steam since the eruption of 1912, indicate that the emanations derive their heat from a deep-seated igneous body. The emanations (now) contain over 99% of steam together with approximately 0.12% of hydrochloric acid, 0.03% of hydrofluoric acid, and 0.03% of H_2S. These acid gases

have greatly altered the pumice in the vicinity of the vents of the fumaroles.

"If we suppose the surface of the particles altered by these vapours and soluble salts of the bases formed, together with gelatinous silica, there is a possiblity that such substances might in some way or other, perhaps at a certain degree of hydration, form a cementing medium, if too much water did not condense on the surfaces of the particles.

"If now the particles coalesce and the mass increases in size in the way you have described, then after the deposit has been formed on the earth we would very likely have conditions necessary for the quick 'rotting' or decomposition of some of the pumice beds, the salts of iron and aluminium decomposing to form hydrates, and the aluminium ultimately giving rise to claylike minerals such as kaolinite.

"It seemed to me that several facts mentioned in the paper might just possibly be explained by the presence in the pumice of soluble salts formed by the agency of acid gases, these salts still being present on the surfaces of the particles at the time of their deposition; for example, from Fig. 1 the presence of interbedded layers of relatively fresh volcanic material might be explained by the absence of such salts at the time of the ejection of the material. Again, the curious alternation of pumiceous layers with (usually iron-stained) tough highly-resistant layers, the latter seemingly forming a not-very-sharply-separated 'cap' to the pumice layer, suggests the idea that each resistant layer might have been formed largely from material derived from the lower layer; for example, by the salt solutions working upwards and depositing their salts at the surface (just as this occurs in dry irrigated areas, e.g., Central Otago). Certain salts of iron and aluminium are easily decomposed and would give rise to hydroxides, and even to clay-like material possibly. (In the neighbourhood of geysers the aluminium is ultimately deposited as alumite or as kaolin.)

"It is significant, too, that the chalazoidites apparently have the toughest and most resistant layer at their surface. Facts in favour of this are:—

(a) The cementing of the 'tail' has already been attributed to such a cause.

(b) Iron oxides (secondary and hydrated?) are at least occasionally present in the laminations of the chalazoidites.

(c) The nucleus (and nucleolus) and the absorbent parts of the laminations might just possibly consist of secondary material produced by the decomposition of the salts, or of gelatinous silica liberated during the formation of the salts—it is indeed just the gelatinous silica, of course, that takes the stain in staining an ordinary rock slice.

(d) The very hard and resistant outermost layer of many chalazoidites suggests, as mentioned before, the possibility of this having been formed in a similar way to the 'cap' of the pumice layers, and in Campbell-Smith's descrip-

tion of the microscopic properties of a chalazoidite he refers to the patches of clay-like material in the outer layers.

"All this is purely speculative on my part. However, I thought it might be worth while further examining some of the samples you sent in for traces of chlorides—sulphur not being strongly in evidence as shown by the analyses. I tested samples 1, 2, and 3 only. Sample 1 had very little chloride soluble in water, but samples 2 and 3 gave very strong tests indeed. However, such chloride would most likely have been derived from the salt spray carried from the sea by the wind over Scinde Island. After removing this chloride, practically no more could be extracted by hot dilute nitric acid, but I was rather surprised to get relatively large amounts of chloride again from all the residues, after decomposing the latter with hydrofluoric and nitric acids, showing that some difficultly-decomposed chloride mineral is present in all. The tests were only qualitative on 1 gm. of sample, but I should think that the amounts of this latter chloride were of the order of 0.1% or somewhat more. Of course, chlorides are not unknown in acidic lavas such as rhyolites and obsidians, but are usually present in traces. But an obsidian from Iceland, for example, is recorded which contains 0.1%, and one tested recently in the Dominion laboratory had somewhat more than this. Further, it is possible, I suppose, for sea-spray salt to have formed a complex mineral with the pumice. So the evidence is quite inconclusive; nevertheless, it would be interesting to know if chalazoidites from other districts, and particularly from inland districts, contained relatively large amounts of chloride or of sulphur."

In order to settle this point with regard to the large amount of chlorine I forwarded to Mr. Seelye samples from a recently-exposed section close to the entrance of the Napier Hospital, and also some chalazoidites from Taupo. The results of the analyses which he kindly undertook are as follows:—

1. Unbroken chalazoidites from upper part of chalazoiditic layer.
2. Matrix of same.
3. Unbroken chalazoidites from lower part of layer.
4. Matrix of latter.
5. Chalazoidites collected in Taupo.

Chlorine in Water—Soluble Chlorides.

	1.	2.	3.	4.	5.
CL.	0.04	0.03	0.03	0.03	0.02 per cent.

Chlorine in chlorides decomposed by dilute nitric acid:—none.

Chlorine in chlorides decomposed only by hydrofluoric acid:—

CL.	0.11	0.11	0.12	0.12	0.11 per cent.

Mr. F. T. Seelye in commenting on these results states that in the published analyses of pumice the presence of chlorine is scarcely mentioned, and probably in most cases has not been looked for.

Washington in his tables of all the published analyses of igneous rocks has only about twenty-six analyses of pumices of various types.

In one vulsinite pumice (silica 5.8%, alkalies 11.8%) a trace of chlorine is present, whilst two analyses of lapilli ejected during the Tarawera eruption show 0.05% and 0.4% of chlorine respectively (S. P. Smith, "Eruption of Tarawera," 1887, p. 76).

On re-examination of a sample of pumice recently sent in by the Geological Survey, Mr. Seelye found only a trace of water soluble chloride and 0.08% in form only decomposed by hydrofluoric acid.

The presence of chlorine in the Tarawera lapilli, in the obsidianite mentioned above, in the Rotorua pumice, and in the present specimens makes it seem quite possible that this element is of widespread occurrence at least in the North Island volcanic district.

The larger chalazoidites from the lower layer were tested for the presence of fluorine. "It is certainly not present in more than very small amounts, and as the method of estimations and even the detection of very small amounts is not very satisfactory, one would hesitate to say that it was present at all."

Dealing with the complete analyses Mr. Seelye states:—

"I have calculated the results of the analyses made here on the five samples into the amounts of those Standard (or Normative) minerals used by many petrographers in calculating the 'norm' of a rock from the analyses. Somewhat similar calculations are used in calculating the theoretical or standard mineral composition of a clay from the analyses. Further information about a rock or clay can sometimes be gained in this way, but the results are to be used with caution. The standard minerals are not necessarily those actually present. I am enclosing the results on a separate sheet. The amounts of silica and of the various felspars may probably be taken as fairly representative of the amounts of these minerals actually present, or potentially so in the pumice glass. The amounts of corundum (Al_2O_3), may possibly here be taken as indicating the relative amounts of clay produced. Beneath the table are given the amounts of the clay molecule kaolinite corresponding to these amounts of Al_2O_3. On this assumption, decomposition has proceeded to a far greater extent in the chalazoidites themselves and in their matrices than in layer 1. The differences in the amounts of (Na_2O+K_2O) between sample 1 and the other samples might then also be accounted for in this way, as also the less amount of H_2O in sample 1. The amounts of magnetite (FeO, Fe_2O_3) are not here truly representative—no doubt, much of the Fe_2O_3 of this 'normative' mineral is really in the form of hydrated oxide of iron, while some of its FeO, and also some of the ilmenite (FeO, TiO_2) is much more likely to be present together with the normative hypersthene in the green and greenish-brown ferro-magnesian minerals that are actually present in all the samples.

"Both the analyses and the 'norms' show that the tendency is for the chalazoidites to have rather less of the bases, especially FeO, CaO, MgO, and MnO, than the corresponding matrices, but the differences are very small. It would seem to suggest the greater attack and removal of ferromagnesian minerals in the chalazoidites."

Results of Analyses of Nos. 1-5 Calculated to the Usual Standard or "Normative" Minerals.

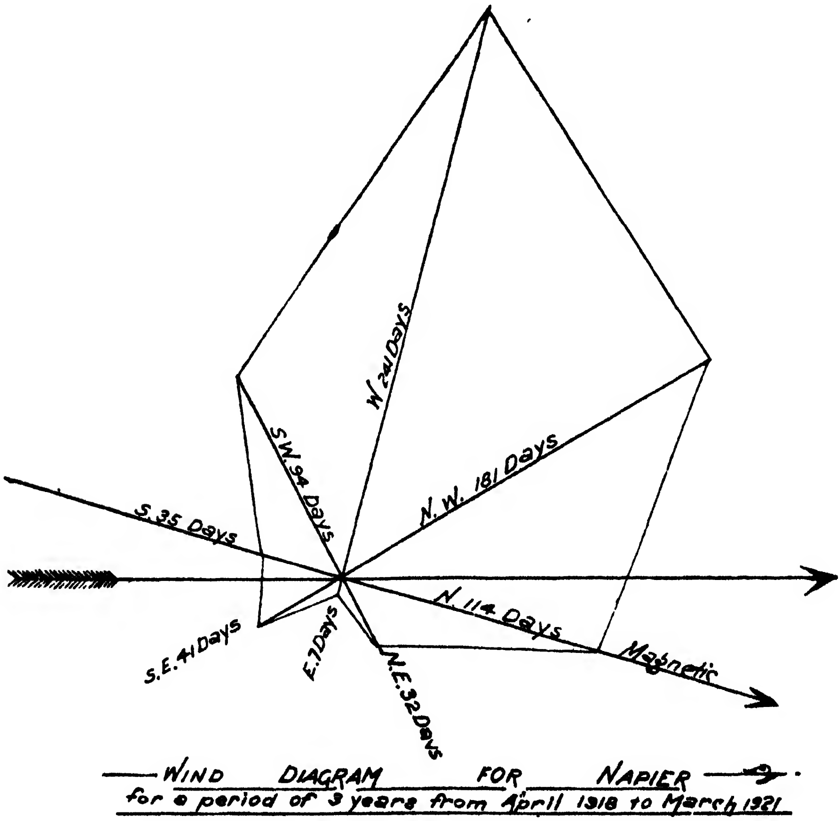
		1		2		3		4		5	
Quartz	SiO_2	35.58		39.78		39,72		39.18		37.98	
Orthoclase	$K_2O, Al_2O_3, 6SiO_2$ ...	17.79		16.12		16.12		15.57		15.01	
Albite	$Na_2O, Al_2O_3, 6SiO_2$ ...	30.92	Felspar 56.49	23.58	Felspar 47.76	23.58	Felspar 48.32	24.63	Felspar 47.71	25.15	Felspar 48.78
Anorthite	$CaO, Al_2O_3, 2SiO_2$ ...	7.78		8.06		8.62		7.51		8.62	
Corundum	Al_2O_3	0.10		1.63		1.53		2.04		1.73	
Hypersthene	$x FeO, y MgO, (x+y) SiO_2$	1.43		1.40		1.63		1.40		1.73	
Magnetite	FeO, Fe_2O_3	1.39		2.09		2.09		1.86		2.09	
Ilmenite	TiO_2, FeO	0.46		0.46		0.46		0.46		0.46	
Haematite	Fe_2O_3	...		...		...		0.16		...	
Water (total) ...	... ...	4.63		6.77		6.37		7.06		7.05	
Minor constituents	... ...	0.15		0.15		0.17		0 15		0.17	
		100.23		100.04		100.29		100.02		99.99	
The amounts of corundum, Al_2O_3, would correspond to the following amounts of the clay mineral: Kaolinite	$Al_2O_3, 2SiO_2, 2H_2O$ (The SiO_2 for this mineral would have to be deducted from the Quartz of the norm, and the necessary water from the total water.)	0.26		4.13		3.87		5.16		4.39	

SITE OF THE VOLCANO OR VOLCANOES.

The question as to which volcano or volcanoes were concerned in the formation of these pumice-beds is one of very great interest, and there can be little doubt that it will be answered and throw much interesting light on the past volcanic history of the North Island. The most important method is to determine exactly the distribution of the chalazoidites. Although it is extremely probable that other periods of volcanic activity have been associated with their formation, if corresponding beds (but thicker than those in Scinde Island) could be traced amongst the vast pumice deposits of the centre of the island, and those along the East Coast, the evidence would be exceedingly valuable.

Chalazoidites occur at various points along the Napier-Wairoa road, at Tangoio the pumice fragments are larger than in Scinde Island, along the Napier-Taupo road, along the Napier-Taihape road, on the Napier-Puketitiri road near Patoka, and on the foothills of the Ruahines. Mr. Hill, since the reading of this paper, has drawn

my attention to the fact that large specimens up to 2.5 cm. in diameter are met with on the banks of the Waikato. An examination of the cutting on the road leading from Taupo, just before the bridge over the Waikato is reached, shows them to be sparsely scattered through a matrix of coarse pumice fragments. Fig. 6 shows some specimens from this locality. They are identical in all respects with specimens from Napier, except that they are larger. Nothing similar to a chalazoiditic layer such as occurs in Scinde Island was found, either here or on a cursory examination in the surrounding district. There were conglomerations of masses of pumice-dust



Total No of Days	Wind Direction Recorded N	NE	E	SE	S	SW	W	NW	Calm	No Record
1096	114	32	7	41	35	94	241	181	344	7

Fig. 5.

several inches across in the midst of the layers of coarse pumice-particles. Of more than passing interest is the presence of water-worn greywacke pebbles in these beds. Mr. L. I. Grange has found chalazoidites at several points in the Rotorua district. Professor Bartram points out that Hewitt (9) in his account of the geological features of the Arapuni district, states that

near the diversion tunnel some small concretions have been noted in the soft pumiceous silt. They are described as being about the size of marbles, and form in little clusters which occur in definite planes of the silt. It is suggested that they were probably formed during floods in sluggish waters by the rolling along of initial sand-grains with accretion of smaller particles. I have not had the oportunity of examining these so-called concretions, but it seems more than likely that they will be found to be chalazoidites. Further examinations will undoubtedly show them to have a widespread distribution. When this distribution has been worked out in detail it will be possible to locate the volcano responsible. In at least one place on the Napier-Rissington road the various layers shown in Fig. 2 can be identified, including the chalazoiditic layer, but it contains no chalazoidites. This is certainly not due to any process resulting in their disintegration, but is explained by the fact that this part of the volcanic cloud contained insufficient water to form chalazoidites, or that some other condition necessary for their formation was absent.

It seems that a study of the prevailing winds might help in locating in which direction the volcano was situated. Fig. 5 is a diagram showing the winds in Napier and their relative frequency of duration. It will be seen that the westerly winds predominate, and if the winds in later Pleistocene times were the same as at present, and there is no reason to suppose any great differences, it would be reasonable to assume that the volcano was situated to the west or north-west of Napier. This would point to the present centres of volcanic activity. The farthest south I have as yet encountered the chalazoidites is towards Moteo, but they extend much farther in a northerly direction. It is clear that even with a constant west wind the pumice deposit in which the chalazoidites occur would spread fanwise from the erupting volcano, so that taking a point due west of Napier would not necessarily locate the situation of the volcano; it could equally be west of points many miles farther north, and several miles farther south. When the depth of these deposits at various points, together with the distribution of the chalazoidites of this particular era of volcanic activity, are approximately known, it will then be possible to locate the volcano with a fair degree of accuracy. The identification of deposits elsewhere must be based on continuity with beds on the mainland having a similar order of deposition to those in Scinde Island, and to a considerable extent on the presence of chalazoidites. If in addition a diagram showing the winds at the suspect volcano could be applied to a map of the North Island, the distribution and thickness of these pumice beds would be found in agreement.

It might appear that each different layer in Fig. 2 owed its origin to a different volcanic outburst, or even that several volcanoes were concerned. It seems unnecessary to assume more than one volcano, or perhaps a group of two or more close together, discharging very similar material. The difference in texture of the layers, and even chemical composition, could easily be explained on the theory of only one volcano. If a volcano discharged perpendicularly a vast quantity of pumice-dust high up into a relatively still atmo-

sphere, forming the well known "mushroom" volcanic cloud, it is clear that, with the crater as a centre, radii could be drawn in all directions, and that at any given point along any radius the coarseness of the pumice-dust would be the same as at any other similar given point along another radius. Let us assume that layer 1, Fig. 2, represents the deposit that would be formed on the 80 mile circle—a distance certainly too great for the deposit of material from the "mushroom" eruption suggested, but since this is roughly the distance of Scinde Island from the present centres of volcanic activity it will do for the purpose of analogy. If now the volcanic eruption increased in violence the lighter particles would be carried farther, and at the 80 mile circle layer 2, a coarser, and for an equal duration of time, a stratum of greater thickness, would be deposited. Similarly, a diminution in intensity of the eruption would result in the formation of a thinner and finer stratum of material. A still more important factor would be the variations in force and changes in direction of the prevailing winds. In addition, changes in the chemical nature and in the sizes of the particles of the material ejected might occur at various phases in the volcanic activity, although this need not be invoked since the selective action of the wind on the various constituents of pumice-dust would be sufficient. The presence of varying quantities of super-heated steam would, however, have a very marked effect on the chemical constitution of the pumice, and this is probably the reason for the differences in the relationship of the amount of magnetite to hydrated oxides of iron, such as limonite, in the various layers. It would also undoubtedly accelerate the change from pumice into the dense layers of pumiceous clays. The effect of varying quantities of water adherent to the particles of pumice on their rate of descent would also be important. Still further, it is likely that periods of intermission of activity would occur, and during these intermissions alterations due to weathering conditions would take place more rapidly in the most superficial layers deposited. For these reasons there seems no need to postulate two or more volcanoes at widely separated points, as with the various factors mentioned all the differences in texture and in chemical composition could be amply accounted for. At present it cannot be definitely stated that more than one volcano was not engaged in the process of formation of these layers, although it seems unlikely and unnecessary.

DURATION OF VOLCANIC DISTURBANCE.

In studying these volcanic deposits it is interesting to speculate as to what length of time was taken in their formation. Was it a period of time covering centuries, or were they deposited comparatively rapidly in the course of a few months? It seems that the latter estimate is the truth. Certain of the layers, such as the chalazoiditic layer, were probably formed in the course of a day or two—perhaps even in a few hours. That there were periods of intermission seems beyond doubt. Apart from the fact that intermissions would be expected during the course of the deposition of beds comparatively so vast, probably 80 miles from the centre of activity, there is evidence from an examination of the beds them-

selves that intermissions actually occurred. The unusual constancy of the layers throughout the whole area of the island seems to be strong evidence of a comparatively rapid deposition. If each different layer were due to a distinct volcanic outburst separated by long periods of time it would be expected that weathering influences would have altered their nature and their stratification to a considerable extent. Certain layers, under the influence of weathering conditions, have become converted into extraordinarily tough reddish clay, which in exposed sections at the present time are particularly resistant to denudation. These, it is suggested, correspond to intervals of intermissions. On this view the first interval of intermission is represented by layer 5. The next would correspond to layer 9. This particular layer merges gradually into the underlying chalazoiditic layer, but it is sharply demarcated above, and its surface presents markings which seem to indicate the action of running water. In the lower part of this layer chalazoidites are firmly imbedded, and since these are of aerial formation there can be no doubt that there were chemical changes from pumice to clay subsequent to their deposition. These chemical changes, it is suggested, would not have taken place except for the influences of atmospheric and aqueous agencies, continued over a period of some time. Layer 13 also corresponds to an interval of intermission, and sometimes one or more beds of clay are found in the pumiceous ash above. These beds, corresponding to periods of intermission, are red or brownish in colour owing to some hydrous oxide of iron (probably limonite), and magnetite does not seem to be present to any extent. Since magnetite is extremely resistant to ordinary weathering conditions it seems probable that the change actually took place in the volcanic crater or in the pumice cloud, and not to any extent *in situ*. There are other iron-stained layers which do not have the nature of pumiceous clay. As has been pointed out, the upper layers of these beds are inconstant, so that probably intervals of intermission were longer, or the nature of the beds rendered them less liable to be converted into pumiceous clays, so that they were more subject to denudation.

MOA-FOOTPRINTS AND MOA-REMAINS.

During the course of excavations for the high reservoir on the Bluff Hill, Mr. Hill found footprints of the Moa in these beds, possibly in one of the layers which represents an intermission. These footprints may be used as evidence that intermissions did occur, and that some type of vegetation must have developed upon which the moa subsisted.

The evidence of Mr. R. H. Finch in dealing with the chalazoidites of Maunaiki, as will be mentioned later, shows that human beings would not necessarily be overwhelmed by the falling volcanic ash, since the impressions of bare feet have been preserved in this layer. The moa would therefore not necessarily be destroyed at once, but would die from starvation.

METHOD OF FORMATION OF CHALAZOIDITES.

In considering the method of formation of chalazoidites there appear to be three possibilities:

(1) They may have been formed in the crater of the volcano.
(2) They may have been formed *in situ.*
(3) They may have been formed in the air, either above the volcanic crater or some distance from it.

The first possibility may be excluded at once. They are not "lapilli" and show no definite evidence of vitrification, except possibly in the outermost layer. In dealing with the second possibility Pratt states, "That these aggregates have not resulted from solution processes is evidenced by the facts that they contain no calcium carbonate nor any other extraneous cementing agent, and that these beds in which they occur have certainly not experienced metamorphism." The question as to whether they were spherulites which had undergone changes coincident with or following on the disintegration of the parent rock was considered. The absence of the radial structure typical of spherulites, and the nature of the beds themselves, overruled this possibility.

Dr. Ohashi, of the Akita Mining College, Akita, Japan, states in a letter that he has studied the method of formation by the following simple experiment. Fine, dry volcanic ash is put on to a dish and then a drop of water is allowed to fall on its surface. By rolling the drop of water about a chalazoidite is formed. I had tried this experiment previously with fine, dry volcanic ash from Scinde Island, and although it is true that a small globular body can be made, it lacks the cohesion and the structure of the true chalazoidite. In the upper part of layer 6 chalazoidites occur intermingled with coarse particles of pumice. It is clear that on the explanation suggested their formation is impossible unless they had been transported by water or wind action from elsewhere, which, in view of the constancy of the layers and their contour following that of Scinde Island, is impossible. There are also the differences in chemical composition of the matrix and the chalazoidites, part of them probably being primary and part due to weathering influences, which would be difficult to account for on this theory. There is also the final and conclusive evidence of Dr. Hovey (9) who found them plastered on the walls of the houses in Precheur following the Martinique eruption, and also the statement of Pratt, already quoted, who has proved that they keep their form on falling into water. It may be taken that the usual method of formation of chalazoidites is not that described by Dr. Ohashi, although it seems a possible explanation under certain conditions. A chalazoidite when once formed, might conceivably shortly after its formation collect further layers in the manner described by Dr. R. Ohashi, and in fact the "tail" that is often present might be evidence that such accretions could occur, although this is not intimately adherent.

Mr. Guthrie-Smith (10) has an interesting paragraph in his book, *Tutira,* in describing the formation of what he called pilules due to raindrops. "About the bases of bare scarps—the unhealed scars of hillside slips—quantities of the finest dust accumulate in dry seasons. On these miniature screes of powdered soil fall the

first great drops of a western shower. The dust slope can neither retain the drops nor instantaneously absorb them. Striking the slope they gather earth particles on their downward course. While thus in motion, as if by miracle they change from liquid to solid. Metamorphosed first into ashen grey, and then into brown balls, these earthen pilules, preserving their shape but changing their substance, race madly downhill, bound downhill no longer clear drops from heaven, but minute circular solid globes of soil. With a faster fall of raindrops the process ends perforce; the dust heap becomes a mud torrent."

HAILSTONE THEORY.

(a) *Theory of Ascents and Descents*: We are now left with the last and only possibility—viz., that they are of aerial formation. One theory I wish to suggest is that the formation of a chalazoidite is analogous to the formation of a hailstone. Quoting from the *Encyclopaedia Brittanica,* 1st edition, "All hail is probably connected immediately with whirlwinds more or less developed, and it is when the hailstorm is one of the phenomena attendant on the tornado or on a great thunderstorm that it assumes its most destructive form. The theory of the formation of hail has been stated by Ferrel in his Meteorological Researches for the Use of the Coast Pilot. The vapour carried aloft by the gyrations of the tornado is below a certain height condensed into cloud and rain, but above that height into snow. Let the raindrops formed below be carried up into the snow region by the powerful ascending currents of the tornado and be kept suspended there a little while and they become frozen into hail. If now these be thrown quite outside the gyrations of the tornado they fall to the earth as a shower of compact homogeneous hailstones of clear ice of ordinary size. If, however, they are caught in the descent and carried towards the vortex by the inflowing current on all sides they are again rapidly carried aloft into the freezing region. A number of such revolutions of ascent and descent may be made before they fall to the earth. While high up in the snow regions the hailstones receive a coating of snow, but while traversing the region lower down where rain yet unfrozen is carried up they receive a coating of solid ice. Thus, alternate coatings of snow and ice are received, and the number of each sort indicates the number of revolutions described before the hailstones fell to the ground."

In the various descriptions of hailstones their size and structure vary in the same way as the chalazoidites.

At the time of the deposition of the chalazoiditic layer there was a vast cloud of pumice over the whole district, including Scinde Island. In this drifting cloud the coarser and heavier particles would be in process of descent at a more rapid rate than the finer and lighter particles at a higher level. The temperature would be relatively high, as pumice is a poor conductor of heat. Each particle of pumice at what might be called the "water-level" in the cloud would be surrounded by a thin film of water. In addition the capacity of air for holding vapour would increase with the temperature. At 30° F. the maximum weight of water absorbed by air in

grams per cubic foot would be 1.94, at 70° F. 7.98, while at 100° F. it would be 19.7. If as a result of a decrease in temperature of the cloud due to dissipation of its heat during its journey towards Scinde Island, or to the meeting of colder currents of air coming from the sea—the land breeze—then condensation of its moisture would occur. These particles of pumice with their moisture under the influence of surface-tension would tend to coalesce to form a nucleolus, and this in turn would aggregate to itself other particles to form a nucleus. This would account for the relatively loose structure of the nucleus. If the graph in Fig. 4 is accurate it is possible to infer that chalazoidites up to about 70 mg. in weight may have had their origin at roughly the same level in the cloud of water-charged pumice-dust, and that the variations up to this size were dependent on the amount of water-vapour immediately available. Chalazoidites more than about 70 mg. in weight owe their size to additional laminae the dense ones possibly composed of finer constituents possessing a lesser specific gravity, and probably with lesser quantities of water, whilst the less dense ones had coarser dust and a greater proportion of water. It is even possible that the particles of pumice-dust forming the nucleus and capsular layers were originally of about the same size, but those that were in the lower part of the cloud were there, partly owing to an increased amount of water, accelerating their descent. This idea alone would explain satisfactorily the differences in density of the laminae, but not the differences in chemical composition, assuming that these differences were present at the time of formation of the chalazoidites. It would not explain the fact that chalazoidites below 70 mg in weight are all definitely laminated in structure. Such factors as the varying specific gravity of the minerals present, the size of the constituent particles, and the amount of water-vapour at various levels, would be operative and need consideration. If the small chalazoidites were carried by an ascending current of air into a layer of more finely-comminuted dust, or dust with a lesser amount of water-vapour, then the dense lamina would be accounted for. If they then fell back through the cloud into the "water-level" a coating of dust, each particle surrounded by water, would result in a lamina that was not so dense. If this process were repeated several times the complete chalazoidites would be accounted for. The essential difficulty of this theory is that if the ascending current were strong enough to raise the partly formed chalazoidite to a higher level it would also carry the coarser particles that composed it to the same level.

For the purpose of testing this theory it was thought that estimations of the amounts of magnetite would be valuable. It would be expected from its more rapid descent, due to its greater specific gravity, that it would be in greater abundance in the matrix than in the chalazoidites, and greater in amount in the small ones than in the large ones. On testing, as explained previously, this actually appeared to be the case. If the possibility of the leaching out of certain constituents, or the possibility of the addition of others were excluded, the differences would be accounted for on the theory that has been outlined. Examination of a large chalazoidite from Taupo

showed the glass-laths to be finer, and the flocculent clay-like particles to be more numerous in the capsular layers than in the nucleus. This again would be valuable evidence in favour of the theory, but these capsular layers are most liable to the decomposition that would produce a similar appearance.

(b) *Theory of Direct Descent*: Ordinary summer hail is merely frozen raindrops, so that this method of formation for the chalazoidites may be invoked. It could be assumed that the chalazoidite commenced as a central nucleus at a level in the pumice-cloud where water was abundant, and that in its descent it passed through various clouds of pumice-dust having varying humidities, and that these each in turn gave alternately a dense or less dense lamina. Another possibility is that a "drop" of water formed around a nucleus of pumice particles and that in its descent it collected films of pumice dust which would result in laminae. On this theory the sizes of the chalazoidite would be dependent on the following factors:—

(1) The height of the water-charged pumice-cloud in which it originated, which would be dependent on the temperature.

(2) The quantity of water and the amount of dust immediately available in this cloud to form a larger or smaller nucleus.

(3) The number and thickness of pumice-clouds through which it passed in its descent.

(4) The relationship of the amount of pumice-dust to the amount of water necessary to form a dense or less dense lamina, or no lamina at all, in passing through these clouds.

Rather against this theory of direct descent are the more or less regular alternate laminae of dense and less dense rings. This would seem to presuppose that clouds containing varying quantities of water occurred at alternate and fairly regular intervals, and that the difference in density of the laminae is dependent on the varying amounts of water surrounding the particles of pumice. A still further curious characteristic is that the laminae appear to be of rather constant thickness, whether dense or less dense. It seems very unlikely that alternate clouds of pumice would occur, as required in this theory. In dealing with this question it seems clear that the smaller chalazoidites do not represent the nucleus of the larger chalazoidites, since they present evidence of lamination, indeed the nucleus of the larger chalazoidites appears to be homogeneous except for the nucleolus.

It seems even possible that both theories of formation may have been operative. The upper part of the chalazoiditic layer, where the chalazoidites are of such constant size, shape, and structure, suggests that their manner of formation was identical, and that the theory of direct descent might be the correct one. In the lower part of the layer, where there is such great divergence in size, the conditions of formation were possibly not identical, and the theory of ascents and descents may be correct. Even then the differences in the amount of water available and the size of the initial mud ball

may be explainable on the theory of direct descent. The drops in a sudden tropical downpour of rain are often first of large size, but later become of uniform size. It is, however, clear in Scinde Island that the first drops were small, and were succeeded later by a mixture of large and small ones, and again later by small drops. Then, of course, the sizes of the drops may have varied in different localities even a comparatively short distance apart. In favour of this theory is the fact that the particles entering into the formation of the nucleus of both large and small chalazoidites appear to be about the same size, and appear to have the same porosity. The argument of the fineness of the constituents of the capsular layer, and the differences in the amount of magnetite cannot be used, as they may equally be due to decomposition influences. The only method of obtaining any satisfactory evidence on this point would be the examination of recently fallen chalazoidites if they were available.

The question now arises as to whether these chalazoidites were formed in the air above Scinde Island or actually over the mouth of the crater. In either case one or both methods described may have been involved in their formation. If they were formed above the mouth of the crater there would be no difficulty in their transportation, as pieces of pumice (even in the dry state) as heavy as the large chalazoidites are abundant in other parts of these layers. There are, however, no coarse fragments of pumice in the chalazoiditic layer, and it is clear from the table showing the gradings that all the material reaching Scinde Island at that time was of fine texture. When the distribution of the chalazoiditic layer is known farther inland it will almost certainly be proved that the pieces of pumice will become progressively larger as the site of the volcano is approached. Were this evidence available it would be proved from their weight that the chalazoidites were formed over Scinde Island. As the position stands at present there is very little doubt that this is what actually occurred. The possibility that the chalazoidites were formed above the volcanic vent, and that the extraordinary density of the capsule is due to the effects of heat and not due to solution processes would supply a simple explanation for their cohesion, but for the reasons already given this seems unlikely for Scinde Island specimens. There is no reason, however, why this explanation should not apply in some cases, particularly to those chalazoidites formed above and falling in the vicinity of the erupting volcano. One other possibility as an explanation for the semi-vitrification of the outermost layer of some of the chalazoidites has to be considered. The pumice-cloud, as already pointed out, would be at a relatively high temperature. It seems probable, with the high-tension electric conditions present, that more heat might be generated from electric discharges round about some of the chalazoidites after their formation, and might result in their outer coats being semi-vitrified. This would explain why some at least retain their cohesion even on falling into water. The evidence against this is, however, conclusive. Any explanation for the cohesion must be universally applicable—the above is not, since not all chalazoidites show evidence of semi-vitrification. In the Martinique eruption the chalazoidites were found plastered against the walls of the houses,

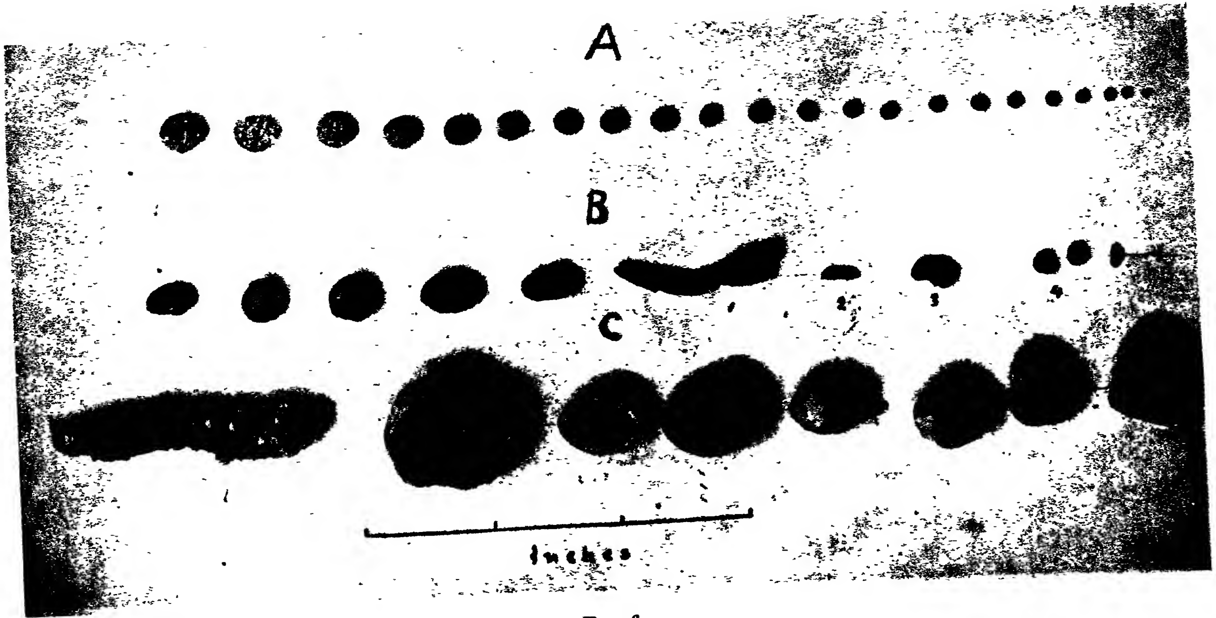


Fig. 6.

A. Chalazoidites of varying sizes from Scinde Island.

B. On the left are Chalazoidites from Scinde Island. The one on the extreme left shows a flattened area, the next shows the "tail" of matrix, the next is a Chalazoidite showing a flattened area due apparently to the impact on striking the ground while on the other aspect is a concave area possibly due to the impact of another falling Chalazoidite. 1 and 2 are tubules; 1 is of unusual size; 3 shows a concave area in the matrix uniting two Chalazoidites; 4 shows two partially disintegrated Chalazoidites with central holes representing the nucleus in each case, while the other is a specimen of the peculiar oat-shaped forms.

C. 1 is a fulgurite with Chalazoidites intimately adherent. The fractured ends show vitrification. The remaining Chalazoidites are from Taupo, the two on the left and the one on the extreme right have been stained with eosin.

Fig. 7.

Chalazoidites from Scinde Island somewhat enlarged which have been sectioned and stained The one in the centre shows the meniscus to which attention has been drawn in the text.

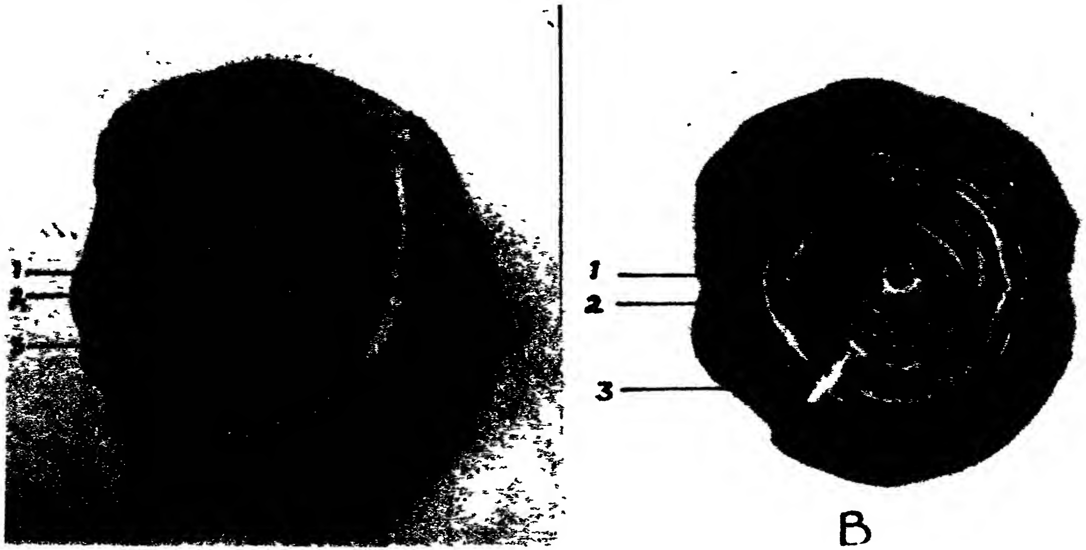


Fig. 8.

(A) Enlargement of chalazoidite at right end of row C, Fig. 6. (B) An X-ray photograph of a section of the same chalazoidite. A great deal of the detail shown in the X-ray film has been lost in printing.

1. The nucleolus in both photographs In the X-ray two densely radio-opaque shadows are present in the translucent nucleolus. In other X-rays the nucleolus is always translucent, and densely radio-opaque material has not been noted before.
2. A densely-staining lamina which is indicated in the X-ray as a less radio-opaque lamina. The line in A has passed too far towards the centre.
3. An incomplete fracture formed either at the line of impact or more probably during the process of drying

and in the island of Maunaiki the chalazoidites have been found squashed out by human footprints. A study of their shapes in Scinde Island and elsewhere is all in favour of most, if not all, being in a plastic condition on striking the earth. The semi-vitrification, whether a primary condition or a secondary condition due to solution processes, is not a sufficient explanation of their cohesion.

There are at least three essential conditions necessary for the formation of chalazoidites:

(1) The presence in the atmosphere of pumice-dust in a fine state of subdivision, and in a certain degree of concentration.
(2) The presence of a considerable proportion of water.
(3) Certain chemical conditions must be present to allow of the chalazoidites becoming coherent on drying.

Exactly what is the relationship between these factors offers a very interesting field for further research. There is no evidence to show that all the water in the pumice-cloud was used up in the formation of chalazoidites; if so, a considerable amount may have descended with the pumice-particles that constitute the matrix. There is possibly another factor involved in the formation of the chalazoidite—viz., the presence of magnetite. In chalazoidites from Vesuvius, as would be expected from the basic nature of the material ejected from that volcano, magnetite is present in larger quantities than in Scinde Island specimens.

After the formation of the chalazoidite one other factor has to be considered—viz., the surface on which they fell. "It is probable that only when they fall on soft unconsolidated beds of recently-fallen tuff is their form preserved under sub-aerial conditions." (Pratt).

LITERATURE DEALING WITH CHALAZOIDITES.

It is an extraordinary fact that in spite of the large amount of literature that has appeared in the past concerning Scinde Island geology, no mention has, up to the present, been made of chalazoidites or of their occurrence in other parts of New Zealand. Mr. W. Kerr drew attention to them in an address to the H.B. Philosophical Society about 20 years ago, but regarded them as having been formed by the action of rain drops following on the pumice dust. There is no doubt that they are of widespread distribution, not only in New Zealand but in other parts of the world, but references in the literature are very few. At the time of reading this paper I was unaware of any previous work having been done on this subject, and it was not until I communicated with Dr. J. Marwick, Government Palaentologist, to whom I am deeply indebted for many useful suggestions, and to Mr. L. I. Grange, Government vulcanologist, that I learned of the existence of the literature, the following references to which they supplied me. As the subject is new to New Zealand and seems worth much further study, I propose to give rather full extracts from the papers that are accessible. The references are:— Hovey in *American Journal of Science,* 14 (1902); Lacroix, *La Montagne Pelee,* Paris (1904); Pratt, *Journal of Geology,* vol. 24 (1916); Jaggar, *Bulletin Hawaiian Volcano Observatory,* 9 (1921);

and Perret, " The Vesuvius Eruption of 1906," *Carnegie Institution Publication* No. 339 (1924).

The account of Dr. Edward Otis Hovey (11), who observed these "drops of mud" after the eruptions on Martinique in 1902, is as follows:—

" In addition to the showers of dry dust and ashes, there fell during the eruption an immense amount of liquid mud which had been formed within the eruption cloud through the condensation of its moisture. This mud formed a tenacious coating over everything with which it came in contact. The drops of mud, too, formed in the air and fell as a feature of the eruption, is proved by the conditions of the walls of the houses in Precheur, on which I found flattened spheroids of dried mud which could have formed only in the manner indicated. These flecks of mud were two, four, and even six inches across, where two or more had coalesced. They occurred mostly on the northern and eastern walls of the houses. The testimony of the people as to the occurrence of rain during the great eruption is conflicting, but the evidence of the coating and these drops of mud proves that much aerial condensation of steam accompanied these outbursts."

As previously pointed out, this account is the most conclusive as to the actual method of formation of chalazoidites.

Wallace E. Pratt, in an article entitled, "An Unusual Form of Volcanic Ejecta" (7), has given the most complete account hitherto of the chalazoidites. In the course of a study of the eruption of Taal Volcano in south-western Luzon, Philippine Islands, during the month of February, 1911, when 1,335 people were killed, he commented on the presence of spherical bodies in the ash fall at the time as follows:—

"An interesting feature of the fall of the ejecta is the formation of drops or balls of mud. These were observed most abundantly on the island itself, but were seen at Talisay and Banadero also. They range in size from large shot to hazelnuts, and when broken sometimes show concentric markings. Apparently they fell late during the activity, being found just below the surface of the deposit. These mud balls cannot be classed as lapilli in the strict sense of that term, since they are built up, probably through the condensation of steam into drops of water."

It will be noted that the chalazoidites are larger than any found in Scinde Island, and that some presented concentric markings. It is certain that staining methods would show this structure to be universal, a fact which Pratt later regarded as characteristic. In a figure of a vertical section taken on the south-west slope of the volcano his chalazoiditic layer is about five inches in thickness; in the lower part the larger chalazoidites occur, while in the upper part are smaller chalazoidites of more nearly uniform size, an arrangement similar to that found in Scinde Island. The two layers are separated by fine volcanic ash.

Later chalazoidites were found on the slopes of Mount Maquiling, an extinct volcano 20 kilometres north-west of Taal. These, in rare specimens, attained a diameter of 4 centimetres, thus being comparable in size with the chalazoidites observed by Dr. Hovey.

On Bondoc Peninsula, Tayabas, and near the Santa Lutgarda iron-mine at Angat Bulacan Province, widely separated parts of Luzon, he found chalazoidites in slightly-indurated tuff dating back probably to the late Miocene. In his description he describes the chalazoidites as volcanic hailstones, and mentions that they are dependent on volcanic disturbances in which large quantities of water-vapour with fine pumice-dust are ejected.

The reference by Jaggar is entitled "Fossil Human Footprints in Kau Desert."

In the spring of 1920 during visits of Maunaiki, Mr. R. H. Finch discovered the prints of naked human feet in old beds of volcanic ash about 6 miles from Kilauea.

" In current exploration of the desert these ancient trails have been photographed and knowledge of them is increasing. The prints are preserved by solidification of the ash mud through the agency of a carbonate or sulphate crust. This is the pisolitic ash which increases in thickness nearer to Kilauea. The pisolitic spheres give evidences of mud rains, and the footprints have invariably been found in the layers showing the solidified raindrops. The squashing out of the mud from under the bare feet is shown in the hardened impressions (Figure 22). . . . There is no possibility of these footprints being modern, for the natives of this high country rarely go barefoot, this ash does not make mud patches to-day, and the solidified shell in which the footprints are lithified was a product of the acid volcanic gases, mingled with mud rains, which were distinctive in the 1790 eruption."*

This is an extremely interesting account, as the flattening out of the chalazoidites under the bare foot shows that they must have been very soft when they struck the earth. It also demonstrates that the concentration of pumice-dust in the air was not so great as to overwhelm a human being. It is interesting also that fossil moa footprints should be found in the volcanic layers of Scinde Island.

In his account of "The Vesuvius Eruption of 1906" (13), Frank A. Perret states:—

" Still farther on, and more especially upon the mountain itself, the down-sweeping ash became conglomerated through condensation of the water-vapour in the crater-cloud, forming balls of soft mud, some as large as an egg. During the two following days the production by this means of 'pisolites' was on a gigantic scale, although they were of small size compared with others found by the writer at Kilauea, and among the ancient ejected material of Vesuvius (Fig. 33)."†

---

*Similar pisolites are abundant in the ash scattered over the Kau desert by the great explosive eruption of Kilauea in 1789. See T. A. Jaggar, *Bull. Hawaiian Volc. Observ.*, 9, p. 114, 1921. Specimens of these collected by H.S.W. in 1920 vary from 2 to 5 mm. in diameter. Pisolites were found also by Lacroix in some ash-beds of Mont Pelée (*La Montagne Pelée*, Paris, 1904, p. 419), and by Pratt at Taal, Luzon (*Jour. Geol.*, vol. 24, p. 450, 1916). (H.S.W.).

†*Note by J. Marwick*: The reference given by Perret in the original is *Bull. Haw. Vol. Observ.*, 8, p. 114, 1290. This is an error. I have given the correct reference above. The H.S.W. stands for H. S. Washington, an American geologist.

In the South Kensington Museum in London I recently had the opportunity of seeing some specimens of chalazoidites which fell at Bellavista, near Portici, during the Vesuvius eruption of 1906. These are about the same size as those occurring in the upper part of the Chalazoiditic Layer in Scinde Island, and present about the same proportion to the matrix. They are, however, very much darker in colour, in response to the more basic material of which they are composed, and there is an increased amount of magnetite. Examination under the microscope shows them to be formed of a "crystal tuff," in contradistinction to Scinde Island specimens, which are formed of a "vitric tuff." In the Monticelli collection from Vesuvius there were specimens which fell during the eruption of A.D. 79, when Herculaneum and Pompeii were overwhelmed. These are remarkably similar to those found by Mr. Hill at Taupo, in appearance, size, and structure. The "tail" to which attention has been drawn was often present. I am informed by Dr. R. Ohashi that chalazoidites are well known in the volcanoes of Japan, particularly Oshima in the Pacific, near Tokyo, although apparently nothing has been written concerning them. From the Volcano Letter (14) it appears that chalazoidites have been described in western Germany.

While this paper was awaiting publication, Dr. J. Marwick kindly forwarded me an account by Drs. A. R. Richards and W. H. Bryan of volcanic mud-balls from the Brisbane Tuff (15). The authors have found chalazoidites, or spheroids as they call them, at Castra on the right bank of the Tingalpa Creek, twelve miles east-south-east of Brisbane. The beds in which they occur are very similar to the "Brisbane Tuff" of Upper Triassic age which is typically developed in and about the city of Brisbane. The account is rather brief, but from the details that are given some very interesting comparisons can be made. The larger chalazoidites were found as seems usually to be the case, in the lower part of the tuff, and the smaller ones towards the top. The largest specimens measured 25-30 mm., and are thus comparable to the Taupo specimens. In separating the chalazoidites from tuff in the middle of the section, by means of sieves with meshes of 11, 9, 6, and 4 mm. respectively, the largest number were in Group C—6 + 4 mm. Practically all the specimens collected from the higher part of the section belonged to Group D—6 + 4 mm. With regard to Scinde Island specimens, I have pointed out the same remarkable uniformity in size and weight of the chalazoidites in the upper part of the Chalazoiditic layer. The explanation of this fact must be left to the meteorologist, and opens up questions of the very greatest interest. The concentric structure was noted, although some specimens were thought to be homogeneous. Staining methods were not employed. I am inclined to believe that concentric lamination is a constant feature of all chalazoidites of whatever size. The density of the outermost layer is mentioned as "a skin of material with a glazed surface" and its probable effect in accentuating differences in chemical composition between the chalazoidite and the tuff in which they are imbedded is suggested. The authors suggest the "hailstone theory" as the probable explanation of the formation of the chalazoidite. They point out that in the volcanic outbursts of Castra and those in

Luzon, where the Taal volcano is actually within a lake, close proxmity to large bodies of water seems to be one of the factors in chalazoiditic formation. This seems likely enough, and should the volcano responsible for the formation of chalazoidites in Scinde Island be found to be to the south of Lake Taupo it would be another case in point.

It was suggested to the authors that these mud-balls from Brisbane, after being formed high above the volcano, became dried and hardened in their final descent through the hotter air nearer the volcanic vent, and the outermost parts in particular became glazed and indurated, and thus gave the mud-balls sufficient strength to withstand the shock of impact, whether they fell into the water of a Triassic lake, or into loose finely-comminuted volcanic ash. They have noted that the short axes are perpendicular to the bedding-planes of the tuff, which they suggest is the result of the pressure of the sediments added to the series. They consider the constant flattening of their chalazoidites to be due to pressure, which seems unlikely to have had much effect, since deformation of a body with a hard glazed outer skin imbedded in volcanic tuff would be difficult. The probability seems that they were in a plastic state on striking the earth.

Pratt has suggested that conditions peculiar to the tropics, such as high temperature and perhaps excessive humidity, are essential in the formation of chalazoidites. The authors are rather in favour of this view. They point out that the cosmopolitan nature of the floras of Rhaetic and Jurassic times, when little difference existed between the plants of such widely separated places as Greenland, Ceylon, and Antarctica, suggests that there was a uniformly moist and hot climate spreading from pole to pole. It was in these tropical conditions that the chalazoidites of Castra were formed.

The occurrence of chalazoidites as far south of the equator as Napier, and as far north as Naples in Pleistocene and in Recent times respectively, disproves the view that tropical conditions are necessary, though a high temperature of the pumice-cloud itself may be important. On the conditions that I have postulated for their formation they should be found in the ejecta of the volcanoes of Antarctica and Alaska as frequently as in the volcanoes of tropical countries. The statement that chalazoidites are a rare form of volcanic ejecta is probably incorrect. It is likely that now that these bodies are begininng to be recognized, they will be found in every volcanic country, and that knowledge of their distribution, both in recent and in geological times, will increase rapidly.

Richards and Bryan *loc. cit.* have considered the question of the centre of the eruption which resulted in the formation of their chalazoidites, and locate the source of activity to the east and south-east of Brisbane (i.e., towards Castra) in a region now foundered below sea-level. It is very interesting that the chalazoidites in Scinde Island are about 80 miles from the nearest present centre of volcanic activity—a greater distance than any hitherto recorded. If the conditions necessary for their formation that I have outlined are correct, there is no reason why they should not be found at even greater distances.

Illustrations show that the Brisbane chalazoidites are very similar to Scinde Island specimens in size and shape, although some are much larger. The series showing decortication resulting from weathering is interesting since fractures are also present. The polished sections show a well defined capsular layer, and also in some specimens, an eccentric nucleolus or nuclear point.

Conclusion.

It seems that a study of volcanic layers will acquire more importance as knowledge of them increases. In an eruption, for example, in Miocene times, where volcanic material had covered a widespread area of country, it seems extremely probable that much valuable information would be obtained as to the contemporaniety of various deposits, and what effect influences such as climate, depth of water, etc., have had in altering the fauna and flora, if this particular volcanic deposit could be identified by its continuity and its physical and chemical peculiarities. The account that has been given of the chalazoidites is incomplete and so far unsatisfactory, but further research will undoubtedly solve many of the intricate problems they present. There is no doubt that chalazoidites show differences in chemical composition, and in physical properties, depending on their sizes, and very interesting graphs could be prepared showing these differences. The explanation of these graphs, and the solution of the problem as to the cause of the cohesion of the chalazoidites, might not only be of value commercially in employing pumice for constructional works, but also give help in explaining their method of formation. If these researches are undertaken the object in writing this paper will have been attained.

In conclusion I wish to offer my thanks to the various people mentioned in this paper, and also to Prof. John A. Bartrum, Mr. and Mrs. Harwood, Mr. P. L. Hickes, Mr. E. A. Aldridge, and to Drs. R. S. R. Francis and A. R. Ford, for very valuable help.

References.

1.—McKay, A., *Geological Reports*, 1879.
2.—Hill, H., *Trans. N.Z. Inst.*, vol. 20, p. 301, 1888.
3.—Hill, H., *loc. cit.*, p. 304.
4.—Jameson, *N.Z. Journ. of Sci. and Tech.*, vol. 2, p. 209, 1917.
5.—Hill, H., *Trans. N.Z. Inst.*, vol. 19, p. 385, 1887.
6.—Hill, H., *Trans. N.Z. Inst.*, vol. 29, p. 571, 1897.
7.—Pratt, W. E., *Journ. of Geol.*, vol. 24, 1916.
8.—Henderson, I., *N.Z. Journ. of Sci. and Tech.*, pp. 225-226, November 1920.
9.—Hewitt, T. C., *N.Z. Journ. of Sci. and Tech.*, vol. 9, p. 277, 1928.
10.—Guthrie-Smith, H., *Tutira*, p. 44.
11.—Hovey, E. O., *Amer. Journ. of Sci.*, vol. 14, 1902.
12.—Jaggar, T. A., *Bulletin Hawaiian Volcano Observatory*, vol. 9, 1921.
13.—Perret, F. A., The Vesuvius Eruption of 1906, *Carnegie Inst. Publication* No. 339, 1924.
14.—The Volcano Letter *Kilauea Report*, No. 856, June 21st, 1928.
15.—Richards, A. R., and Bryan, W. H., *Pro. Roy. Soc.. Queens.*, vol. 39, No. 5, 1927.

Colloid Substances formed by Abrasion.

By P. MARSHALL, M.A., D.Sc., F.G.S.
(Hector and Hutton Medallist).

[*Read before the Wellington Philosophical Society, July 11th, 1928; received by Editor, 26th September, 1928; issued separately, 23rd November, 1928.*]

THAT matter in the colloid state is delivered by rivers to the ocean where it is promptly coagulated, has long been known. It has also lately been shown by Lenher, as a result of experiments on silica submitted to abrasion in an Abbé Ball Mill, that colloid matter could be produced by mere abrasion. In this case, however (Lenher, *Journ. Am. Chem. Soc.* 43 (3), 1921, pp. 391-392), the abrasion was performed under dry conditions. The meal produced by the action of quartz pebbles on quartz sand during 400 hours was digested with water and the solution obtained, which was not completely transparent, was evaporated. The residue was treated with hydrofluoric acid. It was considered that 0.028 - 0.032 gm. of silica had passed permanently into the state of solution.

Twenhofel states that abrasion probably produces matter of colloid dimensions, but the nature and the quantity of it are not estimated. (Twenhofel, W. H. *Treatise on Sedimentation* 1926, p. 87). He also quotes Lenher.

The classical experiments of Daubrèe 1879 (Daubrèe A., *Etudes synthétiques de Géologie experimentale,* Paris 1879, vol. 1, p. 271) were performed with feldspar fragments in pure water, water saturated with CO_2 and with salt water. Some of these were abraded in an earthenware container, others in one of iron. The effect was greatest when the latter was used with pure water. Three kilograms of feldspar were treated in his abrasion machine in 5 litres of water for 192 hours. In that time 2.72 kilograms had been worn into clay. It was found that the solution contained the following substances estimated in percentages, referred to the weight of the original feldspar: potash 0.415, alumina 0.0009, silica 0.0006. Daubrèe states that the oxide of iron formed attacked silicate of potassium which liberated potash. At that time there was no knowledge in regard to the colloid condition of matter. It is notable that Daubrèe showed that the solvent action of salt water on feldspar under the conditions of the experiment is incomparably less than that of fresh water. Joly has subsequently shown that the solvent action of sea water is greater than that of fresh water (J. Joly, *Cong. Geol. Inter.* 8, 1901, p. 779).

Recently when making experiments on the rate of abrasion of greywacke gravel in a Deval machine with the iron containers charged with two litres of fresh water, it was found (*Trans. N.Z. Inst.* 58, 1927, p. 507) that after all the suspended matter had settled from the water employed, during a period of rest of three months it was still coloured though quite transparent. The coloration appeared

perfectly uniform from top to bottom of a column 20 cm. high, and it was concluded that the material which caused the coloration was not affected by gravitation. It was therefore suggested that the effect was due to matter in the colloid state (*N.Z. Journ. of Sci. and Tech.*, 1928, vol. 9, p. 336).

At that time all the solutions available had been so diluted by the measures taken to determine the fineness of grain of the suspended matter that it was not practicable to investigate the supposed colloid material.

Further experiments have now been made and stronger solutions have been obtained. In a particular instance, 5,000 grams of greywacke gravel of the following grades were used: 7.62 - 6.35 cm., 762.5 gm., 6.35 - 5.71 cm., 1694.2 gms., 5.71 - 5.08 cm., 1698.7 gm., 5.08 - 3.81 cm., 799.6 gms., 3.81 - 2.54 cm., 44 gm.

After movement for 24 hours in 2 litres of water at the rate of 32 turns per minute, approximately 1 mile per hour, 307 grams of suspended matter finer than 0.07 mm. in diameter were produced. A dark reddish-yellow but transparent liquid, uniform in appearance throughout, remained after 100 days' settlement.

The liquid was strongly opalescent. When 100 cc. were evaporated, 0.147 grams of material remained on the dish. Of this 0.048 grams were dissolved on treatment with water and were afterwards found to be sodium carbonate. The total amount contained in solution in 3850 cc. of water was therefore 5.66 grams of which 1.31 grams were sodium carbonate, leaving in the water 4.35 grams of suspensoid material which did not settle.

Much of this material was deposited when half of the liquid had been evaporated. Before the residue became dry a gelatinous condition was noticed.

This residue was fused with sodium carbonate and its constituents were estimated by the ordinary methods of silicate analysis, when the substances isolated gave the following percentages. Table 1, No. 1.

TABLE 1.

	1	2	3	4	5	6
SiO_2 ..	38.36	48.72	61.38	62.10	54.48	59.77
Al_2O_3	10.20	12.08	15.32	16.06	15.94	14.89
Fe_2O_3 ..	17.48	21.80	3.85	11.83	8.66	5.92*
CaO	2.04	2.56	3.27	0.28	1.96	4.86
MgO	trace			0.50	3.31	3.74
MnO_2	trace			0.55	1.21	0.09
K_2O	2.86				2.85	2.38
Na_2O	11.02				2.05	3.25
CO_2	7.81					
H_2O	9.58	11.54	10.92	4.50	7.04	2.02
				4.16	various salts	

1. Composition of the total residue.
2. Composition of portion insoluble in water after drying.

* Part as FeO.

3. Recalculation of (2) after reduction of iron to 3.85 per cent. and subtraction of equivalent weight of water.
4. Red clay, J. S. Brazier Challenger Expedition quoted by Clarke (Data of Geochemistry 1916, p. 513).
5. Average red clay Clarke (*l.c.*, p. 514).

In all probability 90 per cent. or more of the iron was derived from the iron container. If the amount derived from the rock is estimated as 3 per cent., there is left 18.80 per cent. as the amount derived from the container. If this were in the form of ferric hydrate it would have 3 per cent. of water combined with it. The material presumably derived from the rock is thus reduced by 21.80 per cent. If the composition is recalculated on the new basis the result in Table 1, No. 3 is obtained.

This result agrees rather closely, as far at least as the main constituents are concerned, with an analysis of abyssal red clay quoted by Clarke (*Data of Geochemistry*, 1911, p. 489) as typical of that material Table 1, No. 4. On the other hand, Clarke (*l.c.*, p. 490) gives a composite analysis of 51 samples of red clay (Table 1, No. 5) by Hillebrand and Sullivan. Here it is noticeable that alkalies which do not appear in Brazier's analysis amount to 4.90 per cent.; with potash in excess of soda.

The tendency of the alkalies to combine with some of the metallic oxides under deep water abyssal marine conditions is, however, demonstrated by the occurrence of phillipsite crystals so frequently in red clay and of glauconite in off-shore sediments. In both of these substances potash is in greater amount than soda.

The similarity of the composition of this colloidal matter to that of red clay is possibly of no importance, as the two main constituents at least have much the same proportions as they have in the average composition of the surface rocks of the earth (Clarke *l.c.*, p. 32). It is, however, suggested that there may be some significance in the resemblance as showing that a possible origin of the red clay may be found in colloid matter, formed by abrasion on coast-lines, which in the state of minute floccoids might well be distributed over the uttermost parts of the ocean.

It is notable that potash is in greater amount than soda in the analyses of shale as quoted by Clarke (*l.c.*, p. 32), the relative amounts being 3.24 per cent. potash and 1.30 per cent. soda. These substances must ultimately have been derived from igneous rocks in which the average relative percentages are potash 2.99 and soda 3.40.

It would seem from this that either the potash silicates are less affected by processes of destruction than the corresponding sodium silicates or that the potash of the soluble sea salts enters into combination with silica more readily than soda. This may be related to the ascertained fact that soil retains the potassium of a solution of salts of that metal (Clarke, *l.c.*, p. 211).

The general occurrence of phillipsite and frequent presence of glauconite, in regions to which colloid matter only could be borne—unless the idea of decomposition of floating pumice be accepted—supports the suggestion that potash contained in the dissolved salts of sea-water can enter into combination with silica and hydroxide of iron and alumina when in the colloid state.

A distinctly different view is put forward by Clarke (*l.c.*, p. 128): "The oozes of the deep sea have been partly leached of their alkalies, but some of the potassium of the original volcanic material has been retained in the formation of zeolites. Nearer land potassium has been used in the formation of glauconite and still nearer when mechanical sediments appear a similar discrimination is evident—sodium is dissolved and potassium is held back."

In discussing the formation of glauconite, Clarke says (Clarke, *l.c.*, p. 578): "Probably in all their occurrences the final reaction is the same, namely, the adsorption of potassium and soluble silica by colloidal ferric hydroxide. In the ocean these materials are prepared by the action of decaying animal matter upon ferruginous clays and fragments of potassium bearing silicates."

Scott makes the following suggestion: "At some stage during the deposition of sediment the latter may contain rock detritus in such a state of decomposition that it readily on hydration assumes a gel form. This gel will consist mainly of silica with subordinate alumina and ferric oxide. Percolating solutions containing alkalies, iron salts, etc., will be liable to diffuse through the gel moss and during this diffusion the salts will undergo differential adsorption. Ferric oxide will be precipitated while potash will be adsorbed in preference to soda. The well-known occurrence of greater amounts of the former in preference to the latter in clays and soils is in favour of this differential action. Finally the gel will harden to give glauconite." (A. Scott, "The application of colloid chemistry to Mineralogy and Petrology," *B.A.A.S.*, 4th Rep. on colloid chemistry, 1921, p. 237).

Harrison and Jukes separated the pumiceous matter in a sample of oceanic red clay by chemical means and state that it was apparently unaltered. This suggests that silicates remain unaltered under deep water oceanic conditions. (Harrison and Jukes Brown, "Chemical Composition of Oceania Deposits," *Q.J.G.S.* 51, 1895, p. 315).

The solution obtained from the container in which the abrasion had been performed was submitted to several tests, as follows:—(1) Ammonia gave no precipitate. This seemed significant seeing that a third of the matter in solution consisted of iron and alumina. (2) Hydrochloric acid even in small quantity at once gave a large precipitate. (3) Flocculation took place quickly when sea water was added. In different tests the substances were mixed in the following proportions:

Sea Water·	*Colloid Solution*:
1	10
10	10
10	1
25	1
250	1

In the last two cases the floccules separated and subsided very slowly. When the sea water was 250 times the volume of the colloid solution ten hours were required for settlement through 5 cm. The floccules broke up at once when the liquid was agitated and subsequently took rather longer to form than in the first instance. (4) When the terminals from a small six-volt electric battery were placed in the

liquid six centimetres apart a distinct aggregation of matter round the positive terminal could be seen in 15 minutes. In 24 hours the liquid was almost colourless and the positive terminal was covered with dark coloured matter. (5) It was found that the substances in solution in the liquid after it had been cleared by the electric current were the same as those in the solution obtained by treating the residue with water, after evaporating the colloid solution. Both of these contained only alkaline carbonates in solution. (6) The amount of CO_2 combined with the alkali in the dissolved carbonate is far greater than the amount of CO_2 in the original water.

The following conditions were also observed: (7) When the iron container is opened after a period of abrasion a strong smell of hydro-carbon gas (acetylene?) is evident. (8) In most instances all the fine suspensoids formed by the action of abrasion become flocculated at once. (9) The suspensoid substances formed by the abrasion described in this paper were graded as follows:

0.07 - 0.04 mm. diameter	31.50 per cent.	96.70 gms.
0.04 - 0.01	24.00	73.68
0.01 - 0.002	26.68	81.91
0.002 - 0.00001*	19.63	60.26
Colloidal + Solution	1.84	5.66

The real nature of the physical and chemical effects of the abrasion of the gravel is not clear. It is, of course, evident that particles of extremely fine material are derived from the greywacke rock and extremely fine particles from the iron container. While the latter will consist mainly of iron there will also be some quantity of iron carbide. Possibly a reaction takes place between the carbide and water and forms the hydrocarbon gas. The oxygen probably combines with the iron. It is possible that carbon from the iron may be the origin of the CO_2 which unites in some quantity with soda. This fact at least is notable. When fine feldspar sand is submitted to abrasion the soda which dissolves from the feldspar does not combine to form a carbonate. When such materials are treated the amount of iron abraded from the container is very small; the soda is not combined with CO_2 and a very small amount of hydrocarbon gas is produced. It is probable that the reaction due to the abraded iron in no way affects the feldspar or other rock constituents.

Daubrèe and Joly (*Int. Geol. Cong.* 1900, 779) have both shown that the prolonged action of water on feldspar dissolves much alkali and silica.

In the action now considered the silica was not in ordinary solution as it was removed by the action of an electric current, and the same is true of the alumina, iron, and the small quantity of lime found in the liquid.

The conclusion thus reached is (1) That the alkali (mostly soda) was dissolved from the feldspar by the mere action of water and afterwards combined with CO_2. (2) That some of the silica and alumina under the affects of abrasion was reduced to colloid dimensions. The quantity of this material of colloid dimensions derived from the gravel amounted to 3.57 gms. in 24 hours.

---

*Settled at the rate of 7.3 cm. in 90 days.

Pleistocene Glaciation of Central Otago.

By H. T. Ferrar, M.A., F.G.S.

[*Read at the Wellington Philosophical Society on 11th July, 1928; received by Editor, 5th September, 1928; issued separately, 23rd November, 1928.*]

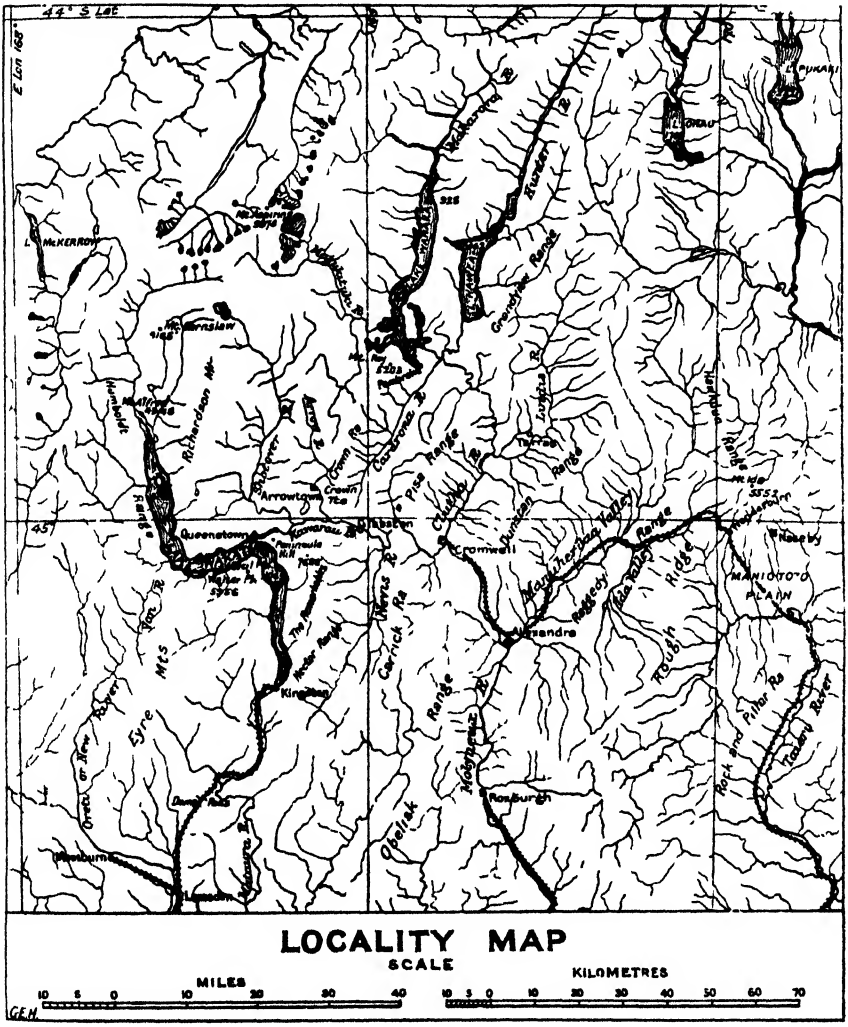
Plate 71.

Signs of a former and greater glaciation than obtains at present in the interior portions of the South Island of New Zealand were observed by the first geologists to explore these regions. Haast (1861*) noticed terraces and transported blocks near Lake Rotoiti in Nelson Province and later when he first reached lakes Pukaki and Tekapo in Canterbury (Haast 1862), he was struck by the fact that the lakes were bordered by lateral and terminal moraines of enormous glaciers that had once extended out from the Southern Alps. Similarly Hector (1863), on his first expedition to the West Coast of Otago recorded the presence of striated rock-surfaces and erratic blocks far removed from present glaciers. Locke-Travers (see Travers 1866) and other geologists who subsequently visited these regions confirm and amplify the observations of Haast and Hector, but differences of opinion have existed and still exist as to the former extent of the ice when it was at its maximum flood-level. The purpose of this paper is to present some new data bearing on the subject, gathered while the writer was making a soil-survey in Central Otago during the past three summer seasons.

The earliest map showing the distribution of ancient moraines was prepared by Haast (1865). It shows morainic accumulations on the flanks of the Southern Alps and includes those on the shores of lakes Hawea and Wanaka, but it does not extend farther south into Central Otago. The next map was that of Hector (1870) which symbolizes ancient moraines on the shores of Lake Wakatipu. At intervals during later years small-scale maps of the South Island were drawn by Hutton (1894), Marshall (1908 and 1912), Park (1910A.), and Morgan (in Mss.), which show their ideas of the former extent of the ice rather than distribution of ancient moraines and of other signs of former glacial action. Park's contention (1909, 1910A, and 1910B) that an ice-sheet of continental dimensions formerly covered Central Otago is at variance with the views of most New Zealand geologists and was opposed by Marshall (1910) on theoretical grounds, by G. M. Thomson (1910) on botanical grounds, and by Benham (1909) on biological grounds. The evidence gathered recently supports Morgan's statement (1926, p. 278) that Central Otago, doubtless owing to light precipitation, was little affected by the ice of Pleistocene times. This evidence will now be catalogued in order from the east side of the district westward to Lake Wakatipu.

*Figures in brackets refer to the appended list of literature.

Maniototo Plain.—On Maniototo Plain no striated rock surfaces, nor isolated mounds of unsorted rock-material that could be called moraines, were seen. Near the portals of the larger gorges of creeks such as the Pigburn, the Sowburn, the Linnburn, the Waitoitoi, etc., flowing off the Rock-and-Pillar Range and Rough Ridge, there are occasional large angular blocks of rock and accumulations of angular



LOCALITY MAP

rock-material. Although these form part of the outwash delta-fans of the creeks, they look like ice-transported debris, for many rock-fragments are standing on edge instead of lying flat as they would do had they been washed out of the gorges.

There are no erratic blocks far out on the plain, but within 20 chains of the hill-edges, especially near the Pigburn and the Stotburn, there are areas littered with erratic blocks of schist five to ten feet

in diameter, and of silicified quartz-grit up to five feet in diameter. Likewise on the north side of the plain there are a few perched blocks on Quartzreef Hill near Naseby, and on Seagull Hill near Wedderburn apparently moved by ice only a few chains from their sources.

The inference from this evidence is that glaciers occupied valleys on the surrounding ranges and that they extended only short distances out on to the plain which was in existence in pre-Pleistocene time.

Ida Valley.—At the south end of Ida Valley there is a low-level lateral moraine of a glacier that once moved out north-eastwards from Low Saddle; and to the south of German Hill Diggings a clutter of wetherstones, consisting of silicified quartz-grit, shows that a short glacier once flowed westwards off Rough Ridge. Farther north near Oturehua undisturbed wetherstones indicate absence of ice-action in this quarter. It would thus seem that during the epoch of former maximum glaciation there were only small valley-glaciers on the surrounding hills and a narrow piedmont-glacier along the south-east and south sides of the valley.

Manuherikia Valley.—Near the north end of Manuherikia Valley the flat top of Tunnel Hill, an isolated hill composed of Tertiary sediments, is strewn with angular greywacke material; evidently this hill was once overridden by ice. Large boulders of greywacke two miles south of Hawkdun Home Station indicate that the front of a glacier from the north once reached this point.

Along the west side of Manuherikia Valley occasional mounds of rock-debris indicate that valley-glaciers from the Dunstan Range once protruded short distances into the valley (see Fig. 1). Along the east side of the valley the only sure indication of former ice-action was seen to the east of Galloway Flat where dislodged wetherstones of Tertiary quartz-grit are strung out westwards on a schist spur.

Erratic blocks on the terraces above Clyde prove, as already stated by Park, that a glacier once flowed out of the Dunstan Gorge. A number of large erratic blocks on the terraces between Springvale Creek and Alexandra show that this glacier extended across the south end of the valley, but there is no evidence that it invaded the gorge of the Molyneux River below Alexandra.

At the ice-maximum then, there were in Manuherikia Valley a fairly large piedmont-glacier at its northern end, a number of short valley-glaciers on its sides and an expanded foot or cats-paw glacier occupying its southern end.

Molyneux Valley.—At Bald Hill Flat to the south of Alexandra there are small terminal moraines of glaciers that once descended from the east side of Obelisk Range, and farther south scattered wetherstones show that somewhat larger glaciers moved out of valleys such as those now occupied by Gorge Creek, Chasm Creek, and Shingle Creek. These glaciers probably ended fairly close to the hills without coalescing and without forming a trunk-glacier in the main valley.

Upper Clutha Valley and Cromwell Basin.—The morainic accumulations at the southern ends of lakes Wanaka and Hawea and at the lower (eastern) end of the Kawarau Gorge near Cromwell

have long been known. More striking than these are the rounded and smoothed schist surfaces of the rocky barrier over which ice has flowed and through which the Matukituki Stream now finds its way into Lake Wanaka. A row of hillocks at the foot of Mount Roy shows similar rounded outlines.

On the north end of Pisa Range an ancient lateral moraine is visible at Mount Barker and there are erratic blocks 1,000 ft. above the valley floor at Luggate and at Queensberry. Farther east at Tarras, on Malvern Downs, and on Bend Terrace, there are stranded moraines at lower levels athwart the Lindis Valley. Morainic debris was found on the eastern flanks of Pisa Range and on the terraces at Lowburn. Morainic debris also occurs, at the same height as the Lowburn terraces, on the flanks of Dunstan Range at Northburn and at other points nearer Cromwell.

This distribution of ancient moraines shows that a stagnant glacier probably occupied the area north of Tarras where Timburn Flat now is, and that large glaciers from the Wanaka and Hawea depressions formerly invaded the Cromwell Basin. These large glaciers, augmented by ice descending the Matukituki and Cardrona valleys, coalesced and spread out over the Cromwell Basin, there to be further augmented by ice shed from the Pisa Range and from the Kawarau Gorge. The thickness of this ice was perhaps 1,000 ft. at Queensberry and 500 ft. at Cromwell. The discharge from it was probably thaw-water, but a small quantity of ice found its way down the Dunstan Gorge as a narrow glacier, which after receiving additional ice from the Dunstan and Obelisk ranges, spread itself out towards the place where Alexandra now stands, as the cats-paw glacier mentioned above in Manuherikia Valley.

Lower Shotover Depression and Wakatipu Basin.—Many geologists have noted the abundant evidence of former ice-action in the Lower Shotover depression and in the Wakatipu Basin and some of them, notably Hector (1863, 1865, 1870, 1873), Haast (1865), Hutton (1873), Andrews (1905), and Park (1909, 1910), have used this evidence in attempts to prove that such depressions were excavated by glaciers. Although Hector insisted (1874, p. 375) that the Wakatipu trough was glacially excavated, he had shown rightly some time previously (1870, p. 372) that the basins of Central Otago were due to dislocations and were in existence before the Pleistocene glacial advance. Enormous excavation implies enormous glaciers, hence various estimates have been made of the thickness the ice attained. That the district was not buried beneath an ice-sheet seems certain, hence signs of maximum ice-flood level should be sought on the mountains forming the sides of the pre-glacial intermontane basins.

Signs of glacier action in the Lower Shotover-Wakatipu district are abundanat at low levels but at high levels they are hard to find. Striated rock-surfaces are rare, the best seen in this district being exposed in an abandoned gold-sluicing claim on the outer edge of Crown Terrace at a height of about 2,000 ft. above sea-level, or 1,000 ft. above the floor of the Lower Shotover depression. At this height also erratic blocks of granite and other rocks foreign to the district were seen at three points on the outer (western) edge of Crown Terrace, but no morainic material was noted along the inner or east

side of the terrace where it abuts against the Crown Range. A great quantity of morainic debris was, however, found 1,000 ft. higher, tucked away in Bracken Gully, a tributary of the Arrow River. From this evidence one pictures the upper Arrow valley filled with ice to about the present 3,000 ft. contour. A tongue of this ice crept up Bracken Gully there to stagnate and melt away, the thaw-water escaping on to Crown Terrace by way of the pre-glacially beheaded First Burn valley. The main discharge of this Arrow Glacier was south-westwards into the eastern end of the Lower Shotover depression which was occupied by a mer-de-glace 1,000 ft. thick. Morven Hill (2,443 ft.) appeared as a nunatak projecting 200 ft. above this mer-de-glace (see Fig. 2), Slope Hill (2,031 ft.) was buried at maximum ice-flood.

Farther west at the north-west corner of Lower Shotover depression, unsorted boulder-clay covers a hill nearly 2,000 ft. above sea-level, but no signs of ice-action were seen on Skippers Saddle (3,200 ft.) The mammilated surface on Skippers Saddle, described by Park (1909) and figured by Cotton in his Geomorphology of New Zealand and by both ascribed to ice-action, is merely a collection, a maze, of conical hummocks of dislodged and slumped schist. No rock-fragments foreign to the district were seen here and the ice-shorn crag figured by Park is unshorn! The glacier that occupied the Shotover valley and deposited foreign rock-material on the terraces at Skippers, therefore did not spill over Skippers Saddle but flowed past Arthur Point and merged into the Lower Shotover mer-de-glace which at this end may have reached up to the present 2,500 ft. contour.

Away to the west signs of former glaciation at high levels are perceptible at the upper end of the Wakatipu trough. The rounded outline of Mount Alfred (4,548 ft.) is evidence that this hill was overridden by ice; and to the south of this point the appearance of the eastern face of the Humboldt Range suggests that maximum ice-flood level reached to about two-thirds of the way up, say 5,000 ft. above Lake Wakatipu. To the south of Humboldt Range the slopes of Mount Nicholas and in the Von Valley give the impression that here glacier tongues had protruded south-westward into Oreti Valley. Farther east, in the middle reach of Wakatipu trough, the flowing contours half-way up Walter Peak and Cecil Peak indicate that ice attained to a height of about 3,000 ft. Opposite these peaks on the north side of the trough, Park (1910A) records boulder-clay 2,000 ft. above the lake on Queenstown Hill. Farther east again, Peninsula Hill (2,768 ft.), the "Crag-and-Tail Hill" of Park (1909), at the east end of the reach, shows remarkably fine glacier-shorn surfaces and was probably overridden by ice.

Along the western face of The Remarkables, no horizontal features or "ridgings" are noticeable, such as should be developed by a glacier nearly filling the Wakatipu depression. There are, however, a great number of erratic blocks in Strath Gyle, a longitudinal valley at the foot of the range. To the south of The Remarkables the lower slopes of the Hector Range have smooth outlines from the shore of Lake Wakatipu up to a height of about 2,000 ft. This smooth zone becomes narrower as Kingston is approached and almost

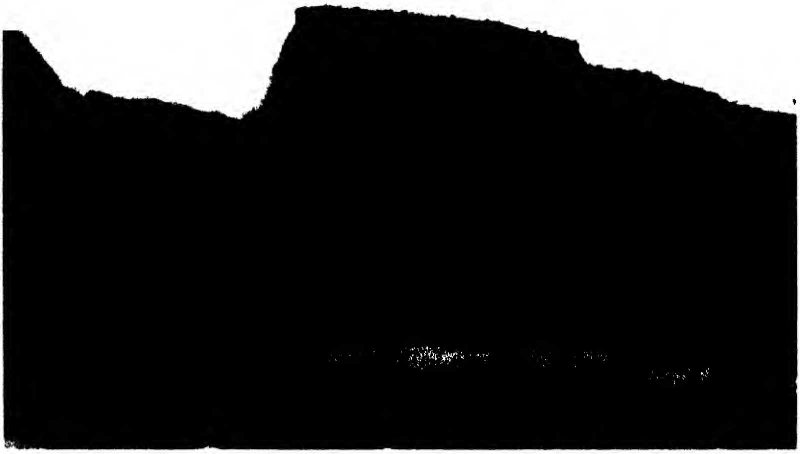


Fig. 1.—Morainic debris overlying Tertiary sediments at Tinker's on west side of Manuherikia Valley. The water in the foreground fills the abandoned Sugar Pot sluicing claim.

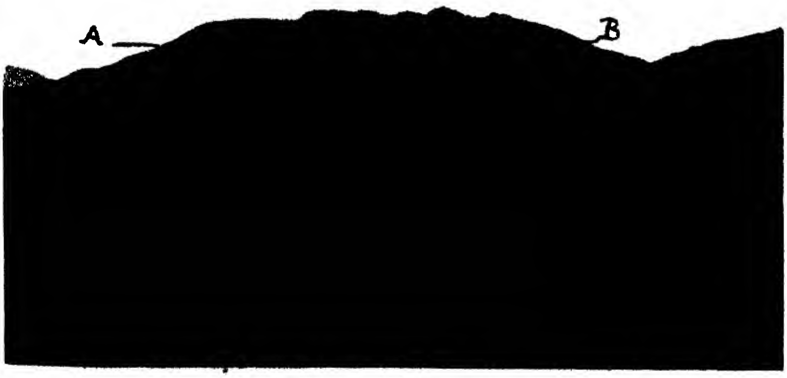
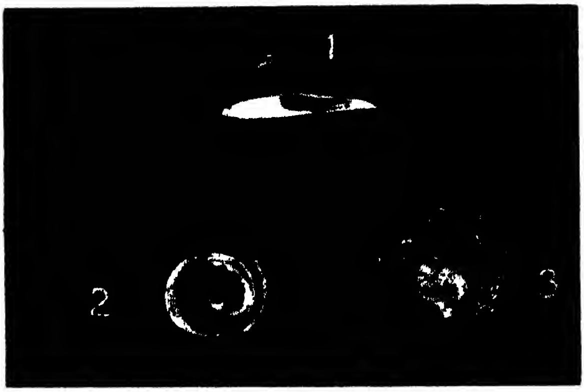


Fig. 2.—Morven Hill, Lower Shotover Depression. No foreign rock-material was found above the line A—B.

Face p. 618.



Sigapatella terraenovae Peile.
Fig. 1.—Holotype. Figs. 2, 3.—Paratype. Type shells in British Museum.

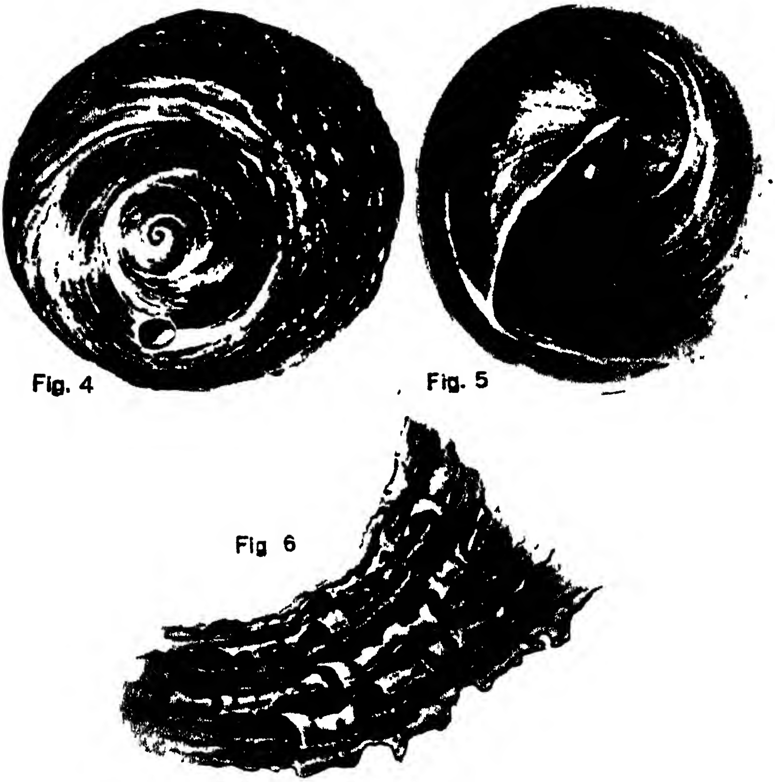
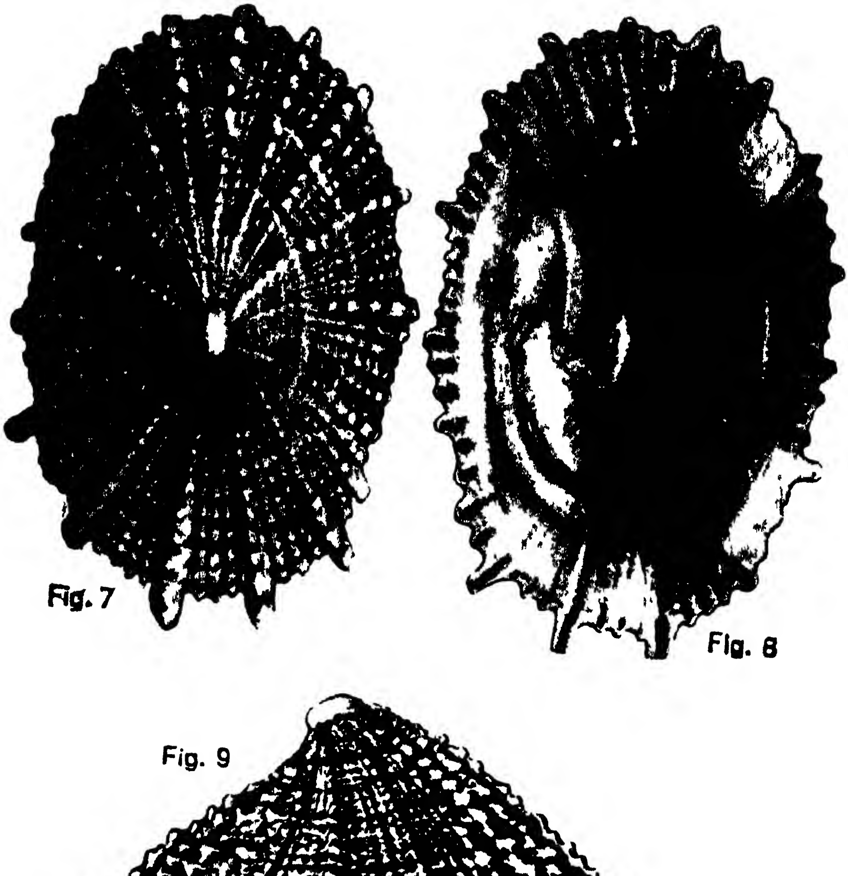


Fig. 4.—Outer surface. Fig. 5.—Inner surface. Fig. 6.—Epidermis.
Compared with Types in Brit. Mus.



FIGS. 7-9.—*Montfortula lyallensis* n. sp. Holotype.

merges into the Kingston moraine. The moraine in its turn merges into river-terraces on which are scattered numerous erratic boulders.

The ice of the great glacier that once occupied the Wakatipu trough was thus apparently 5,000 ft. thick at its upper end, and thinned to 3,000 ft. at the eastern angle of the basin where some of it was discharged into the Lower Shotover depression. This ice, together with the overflow from the Lower Shotover mer-de-glace, invaded the Gibbston basin and made its way down the Kawarau gorge as a narrow sinuous glacier. A glacier in the Nevis Valley probably did not reach the Kawarau gorge. Another portion of the Wakatipu glacier flowed down the Kingston reach of the trough and may have extended 20 miles down Mataura valley to near Dome Pass where the Mataura River enters a gorge. There was probably a lens of stationary ice in the bottom of the Wakatipu trough (now 226 ft. below sea-level) over which the moving portions of the Wakatipu glacier slid.

The Pleistocene glaciation of Central Otago was followed by a period of river erosion when moraines were destroyed and river-terraces were formed (cf. Speight 1911). The collection of great erratic blocks on the valley-floor of the Clutha at Queensberry, the erratics on Victoria Flat near Gibbston, and the line of erratics stringing out from the portal of the Kawarau Gorge at Ripponvale indicate that there was a second but smaller advance of ice subsequent to the formation of the river-terraces. This is in agreement with the observations of Hutton (1875), McKay (1893, 1894), Bell and Fraser (1906), Cox (1926), and Speight (1926, 1928) in other parts of the South Island.

Cause of the Pleistocene Glaciation.—The cause of this Pleistocene glaciation is not known. Possibly it was a general lowering of temperature. Hutton (1876) thought a reduction of more than 10° F. would be necessary, but on palaeontological grounds could not admit that such had taken place. Benham (1909) likewise holds that there was no general reduction of temperature at or about this period. A general lowering of temperature of 4° C. to 6° C., as postulated by Morgan (1926), would have affected regions at a distance from New Zealand. One of the many difficulties this postulate entails is that it conflicts with conditions in Ross Dependency where the former high flood-level of ice was probably due to higher temperatures and the present dessication to extreme cold (Ferrar 1905, 1925). On the other hand lower temperatures in these high latitudes would intensify the indraught of air from high levels (katabatic winds) and might cause ice to accumulate instead of decrease as at present. Murray (1894) was the first to draw attention to the observations of Ross and others as indicating that anticyclonic conditions and out-flowing winds predominate in high southern latitudes, and lately Hobbs (1911, 1926) has advanced a theoretical explanation of such conditions to account for the present glaciation of Greenland and Antarctica. If an intensified downdraught of air from high levels is competent to increase the quantity of ice in the Antarctic then a general lowering of temperature becomes a reasonable explanation of the former glaciation of Central Otago. As, however, the rarified upper air contains hardly sufficient

water-substance to account for the present 7 in. to 8 in. of precipitation on South Victoria Land, intensified katabatic winds would not cause an ice-flood there. Hence general reduction of temperature does not satisfy.

Another possible cause is elevation of the land. The following are estimates, by writers on this subject, of the uplift required to produce the former greater glaciation;—4,000 ft. to 5,000 ft. (Travers 1874), 3,000 to 4,000 ft. (Hutton 1876), 2,000 ft. (Hector 1863), 1,000 ft. to 1,500 ft. (Morgan 1926), 600 ft. (Speight 1908). Morgan's estimate is suported by Henderson (1924) who considers that in the early Pleistocene New Zealand was 1,000 ft. higher than it is now. Since the terminal faces of glaciers near The Hermitage on the east side of the Southern Alps are at about 2,300 ft. above sea-level and the once ice-covered terraces at Alexandra are at about 700 ft., the difference, or an elevation of 1,500 ft. to 1,600 ft. seems sufficient to account for the Pleistocene extension of the glaciers of Central Otago.

LITERATURE.

ANDREWS, E. C., 1905. Some Interesting Facts Concerning the Glaciation of South Western New Zealand. *Rep. Aust. Assoc. Adv. Sci. 1904*, vol. 10, pp. 189-205.

BEAL, L. O., 1871. On the Disposition of Alluvial Deposits on the Otago Gold Fields. *Trans. N.Z. Inst., 1870*, vol. 3, pp. 270-8.

BELL, J. M. and FRASER, C., 1906. The Geology of the Hokitika Sheet, North Westland Quadrangle. *N.Z. Geol. Survey Bull, No. 1.* See pp. 85-86, 98.

BENHAM, W. B., 1909. (In discussion, Otago Institute) *Proceedings N.Z. Inst., Part III*, pp. 80-1. See here remarks of G. M. Thomson (pp. 79-80) and of P. Marshall (p 81) expanded later into their papers published in 1910.

COX, P. T., 1926. The Geology of the Rakaia Gorge District. *Trans. N.Z. Inst.*, vol. 56, pp. 91-111. See pp. 106, 109.

DOBSON, A. D., 1872. On the Traces of Ancient Glaciers in Nelson Province. *Trans. N.Z. Inst., 1871*, vol. 4, pp. 336-41.

—— 1874. Notes on the Glacial Period. *Trans. N.Z. Inst., 1873*, vol. 6, pp. 294-7.

FERRAR, H. T., 1905. Notes on the Physical Geography of the Antarctic. *Geographical Journal*, vol. 25, pp. 373-82. See p. 382.

—— 1907. Report on the Field Geology of the Region Explored during the "Discovery" Antarctic Expedition. *National Antarctic Expedition 1901-4, Brit. Mus. (Nat. Hist.)*, vol. 1, Geology, pp. 1-100.

—— 1925. The Geological History of Ross Dependency. *N.Z. Jour. Sci. & Tech.*, vol. 7, pp. 354-61. See p. 360.

HAAST, J., 1861. *Explorations of the Western Districts of the Province of Nelson.* Printed by C. & J. Elliott, Nelson. See p. 90.

—— 1862. Notes on the Geology of the Province of Canterbury, N.Z. *New Zealand Government Gazette, Province of Canterbury*, vol. 9, No. 18, pp. 121-31. See p. 129.

—— 1865. Notes on the Causes which have led to the excavation of deep Lake-basins in Hard Rocks in the Southern Alps of New Zealand. [Abridged.] *Q.J.G.S., 1864*, vol. 21, pp. 129-37.

HECTOR, J., 1863. Geological Expedition to the West Coast of Otago, New Zealand. *Otago Provincial Government Gazette*, vol. 6, No. 274, pp. 435-78. See pp. 457, 462.

—— 1865. On the Geology of Otago, New Zealand. *Q.J.G.S., 1864*, vol. 21, pp. 124-8.

—— 1870. On Mining in New Zealand. *Trans. N.Z. Inst., 1869*, vol. 2, pp. 361-84. See pp. 370-2.

HECTOR, J., 1873. Address Well. Phil. Soc. *Trans. N.Z. Inst., 1872*, vol. 5, pp. 407-24. See pp. 420-2.

—— 1874. Address Well. Phil. Soc. *Trans. N.Z. Inst., 1873*, vol. 6, pp. 367-76. See p. 375.

HENDERSON, J., 1924. The Post-Tertiary History of New Zealand. *Trans. N.Z. Inst.*, vol. 55, pp. 580-99.

HOBBS, W. H., 1911. *Characteristics of Existing Glaciers.* The Macmillan Co., New York. See pp. 287-8.

—— 1926. *The Glacial Anticyclones.* The Macmillan Co., New York.

HUTTON, F. W., 1873. On the Date of the Last Great Glacier Period in New Zealand and the Formation of Lake Wakatipu. *Trans. N.Z. Inst., 1872*, vol. 5, pp. 384-96.

—— 1875. *Geology of Otago.* Mills, Dick & Co., Dunedin. See pp. 62-64, 67-70.

—— 1876. On the Cause of the former great Extension of the Glaciers in New Zealand. *Trans. N.Z. Inst.*, vol. 8, pp. 383-7.

—— 1894. Glaciation in Australasia. II. New Zealand. *Rep. Aust. Assoc. Adv. Sci., 1893*, vol. 5. pp. 232-40.

MCKAY, A., 1893. Geological Explorations of the Northern Part of Westland. *Parliamentary Paper C.—3*, pp. 132-86. See pp. 158, 162, etc.

—— 1894. On the Geology of the Northern Part of Westland. *Rep. Geol. Explor. during 1892-93*, No. 2, pp. 11-50. See pp. 43, 45, etc.

M'KERROW, J., 1871. On the Physical Geography of the Lake Districts of Otago. *Trans. N.Z. Inst., 1870*, vol. 3, pp. 254-63.

MARSHALL, P., 1903. The Kingston Moraine (N.Z.). *Trans. N.Z. Inst.*, vol. 35, pp. 388-91.

—— 1908. Notes on Glaciation in New Zealand. *Rep. Aust. Assoc. Adv. Sci., 1907*, vol. 9, pp. 283-5.

—— 1910. The Glaciation of New Zealand. *Trans. N.Z. Inst., 1909*, vol. 42, pp. 334-48. See also *Proceedings N.Z. Inst., Part III*, p. 81, 1909.

—— 1912. *New Zealand and Adjacent Islands.* Handbuch der Regionalen Geologie. See p. 48.

MORGAN, P. G., 1908. The Formation of Glacial Valleys and Lakes in Southern New Zealand. *Rep. Aust. Assoc. Adv. Sci., 1907*, vol. 9, pp. 455-6.

—— 1926. The Definition, Classification, and Nomenclature of the Quaternary Periods. *N.Z. Jour. Sci. & Tech.*, vol. 8, pp. 273-82. See pp. 278-9.

MURRAY, J., 1894. The Renewal of Antarctic Exploration. *Geographical Journal*, vol. 3, pp. 1-37. See p, 17.

PARK, J., 1909. The Geology of the Queenstown Subdivision. *N.Z. Geol. Survey Bull. No. 7.* See Chapter III.

—— 1910A. *The Geology of New Zealand.* Whitcombe and Tombs, Christchurch. See pp. 182, etc., 196.

—— 1910B. The Great Ice Age of New Zealand. *Trans. N.Z. Inst.*, vol. 42, pp. 589-612. See also *Proceedings N.Z. Inst., Part III*, pp. 73-75 and 79, 1909.

SPEIGHT, R., 1908. Some Aspects of the Terrace-development in the Valleys of the Canterbury Rivers. *Trans. N.Z. Inst.*, vol. 40, pp. 16-43.

—— 1911. The Post-glacial Climate of Canterbury. *Trans. N.Z. Inst.*, vol. 43, pp. 408-20. See also other papers in later volumes.

—— 1926. Varved Glacial Silts from the Rakaia Valley. *Records Cant. Mus.*, vol. 3, pp. 55-81.

—— 1928. The Geology of the Malvern Hills. *Memoir No. 1, Department of Scientific and Industrial Research.*

THOMSON, G. M., 1910. Botanical Evidence against the Recent Glaciation of New Zealand. *Trans. N.Z. Inst.*, vol. 42, pp. 348-53. See also *Proceedings N.Z. Inst., Part III*, pp. 79-80, 1909.

THOMSON, J. T., 1874. On the Glacial Action and Terrace Formations of South New Zealand. *Trans. N.Z. Inst., 1873*, vol. 6, pp. 309-32.

TRAVERS, W. T. L., 1866. On the Formation of Lake-basins in New Zealand. *Q.J.G.S.*, vol. 22, pp. 254-60.

—— 1874. On the Extinct Glaciers of the Middle Island of New Zealand. *Trans. N.Z. Inst., 1873*, vol. 6, pp. 297-309.

A Note on *Sigapatella terraenovae* Peile. A new *Montfortula*.

By Marjorie K. Mestayer, Dominion Museum, Wellington, N.Z.

[*Read before the Wellington Philosophical Society, 27th June, 1928; received by Editor, 16th July, 1928; issued separately, 23rd November, 1928.*]

Plates 72, 73.

The two species here dealt with belong to two widely different families, yet both have a comparatively simple shell, and apparently similar habitat.

The *Sigapatella* appears to live below low-water mark, as so far I have seen no reference to its discovery within the tidal zone.

The *Montfortula* also probably lives well below low-water mark, and this solitary specimen was washed up among rubbish. I have collected around Lyall Bay for many years, but have never seen it alive.

I would most gratefully acknowledge my indebtedness to Lieut.-Col. A. J. Peile, and Mr. G. C. Robson for the photograph of the type tablet of *Sigapatella terraenovae,* in the British Museum Collection. Also to Miss J. K. Allan for her drawings of two other specimens of *S. terraenovae* and the drawings of the *Montfortula.*

Dr. H. J. Finlay has figured a Curvier Island specimen, but the two specimens from off the Hen and Chickens Islands, 50 fathoms, that Miss Allan has drawn, were picked from those Lieut.-Col. Peile compared with the type material in the British Museum; so their identity is indubitable. These drawings had been made before I saw Dr. Finlay's paper.

Sigapatella terraenovae Peile. (Figs. 1-6.).

Proc. Mal. Soc., vol. 16, p. 21-22. *Trans. N.Z. Inst.*, vol. 57, p. 391-392. Pl. 18, Fig. 1-2, Finlay.

The type of this species was obtained by the British Antarctic (Terra Nova) Expedition, 1910, in a dredging (Station 134) near North Cape, New Zealand, in 11-20 fathoms. They got several specimens, which the late Mr. E. A. Smith determined as Sigapatella calyptraeformis (Lam.); but a study of the radulae of the Australian *S. calyptraeformis* in comparison with the New Zealand species convinced Lieut.-Col. A. J. Peile that he had two different species to deal with. He accordingly, in the above reference, described the New Zealand specimen, and figured the radulae.

In order to get confirmation of Dr. J. Marwick's and my own determination, I sent specimens to Lieut.-Col. Peile asking if they were correct. He confirmed our identification and I herewith give figures of two of the specimens he saw. Also, through his and Mr. Robson's kindness I am enabled to publish figures (Figs. 1-3) of the Holotype and 2 Paratypes from the British Museum Collection.

As the *Proc. Mal. Soc.* are not readily available for New Zealand workers I append the author's description:—

"The shell is almost circular in plan; apex prominent, distant about one-third diameter from the circumference. Whorls 4½, convex, rapidly increasing, but not as rapidly as in *S. calyptraeformis.* Suture well marked. Nepionic shell sculptured with half a dozen spiral grooves, interspaces slightly pitted. Sculpture of rest of upper surface of shell consists of strong, rugose, oblique growth ridges (rather less than 1 mm. apart on the last whorl). In the interspaces are half a dozen finer, wavy growth marks. Under surface is concave; base of last whorl is convex near the axis and concave near the circumference, so as to form a gutter inside the periphery, which is fairly sharply keeled. Basal margin oblique, thin, and sharp, slightly reflexed near the axis to cover a minute umbilical chink resembling that of *calyptraeformis,* but smaller. The whorls are so coiled as to leave a free axial channel between base and apex like that found in *S. tenuis* (Gray), but not so open owing to the axis not being so central. The upper surface of the shell is white, tinged with purple on the earlier whorls, and is covered with a thin yellowish periostracum bearing scattered spine-shaped processes based on the main growth ridges ,spines 1 to 2.5 mm. apart on the last whorl). The base is white, tinged with purple, with a brownish band near the periphery. Diam. maj. 26, min. 23, alt 8.5 mm.

"The radula of *S. terraenovae* has forty-seven rows in the type specimen. The lateral tooth has a broadly triangular point, whereas in *S. calyptraeformis* (with an average number of thirty-four rows) the denticles fringing the inner and posterior edges of the lateral extend to the point.

"The shell differs from that of *calytraeformis* in that the suture is less well marked, although the convexity of the upper surface persists to the periphery, whereas in the latter species the surface flattens towards the circumference, resulting in a sharper keeling of the last whorl. Further differences exhibited by *calyptraeformis* are as follows: The growth ridges are smoother and closer together; the periostracum is brown and much more dense, the processes springing from the growth ridges forming a continuous succession of square-ended blades; the base, though tinged with colour in young shells, is white in the adults examined.

"*S. novaezelandiae* Lesson, can always be distinguished from the other species mentioned above by the presence of a small depression, or false umbilicus, near the axis of the shell. The periostracum is dense and quite unlike that of *terraenovae.*"

Montfortula lyallensis n. sp. (Figs. 7-9.).

Shell, small, oval, left side nearly straight, right side slightly convex. *Anal rib,* just on right of centre line. *Apex,* nearly central, curved backwards, smooth, polished. *Sculpture*: Sixteen primary ribs, starting just below the apex; of these the anal and the one on its left run together and form a faintly-raised inverted V on the apex; in all the interspaces are three thread-like riblets. The three posterior ribs are the strongest and project farthest at the margin. There are about 13 concentric threads, which vary slightly in strength.

On the main ribs these form rounded upstanding nodules, and similar, but very much smaller ones are formed on the interstitial riblets, with squarish pits between them. *Colour*: White, apex, the front 4 ribs and 6th and 7th on each side grey-green, some of the nodules darker than others. When held to the light 4 dark wedge-like rays show; the laterals being darkest, and the posterior much the lightest. *Interior,* porcellanous, glossy, the mushroom-shaped muscle-scar distinctly visible; the colour is rather obscured by a whitish film, as if decaying animal matter had affected it; but through it the dark green outline and incurved scar are visible. The anal groove runs almost to the apex. The colour-bands show clearly at the margins, between them, and surrounding the muscle-scar, the shell is creamy-white. *Margin,* crenulate, denticulated by the main ribs which are more or less projecting, especially the posterior three. The annal groove forming a slight notch.

Measurements: Length 13 mm., width 4 mm., height 5 mm.

Locality: Lyall Bay, Cook Strait. I found this specimen some years ago, among drift material, washed up near the top of the beach.

Holotype, in my collection.

Remarks: On comparison of this new species with *Montfortula conoidea* (Reeve) from Sydney, N.S.W., the most striking difference lies in the sculpture. In *M. conoidea* the primary ribs are weaker and the interstitial riblets stronger than in *M. lyallensis,* also the margin of *M. conoidea* is evenly crenulate The nodules on the ribs also appear to be weaker in the Australian species. Through the kindness of Prof. J. A. Bartrum I have been able to compare his *Montfortula kaawaensis* with my specimen. The fossil is much smaller, lower and smoother, than *M. lyallensis*; but the characteristic muscle-scar is the same in both. In *M. kaawaensis* the strongest ribs are anterior, while in *M. lyallensis* they are posterior.

In part 2 of this volume, p. 235, pl. 41, figs. 34-35, Dr. Finlay describes and figures *M. chathamensis,* from which *M. lyallensis* differs in sculpture, the ribs being sharper, with greater marginal projection. The shell is very much narrower in proportion to length, and with a very different profile.

New Microscopic Details of Certain New Zealand Loricata

By C. E. R. BUCKNILL, L.M.S.S.A., Lond.

[*Read before the Auckland Institute, 31st July, 1928; received by the Editor, 22nd August, 1928; issued separately, 30th November, 1928.*]

Ocelli in *Eudoxochiton nobilis* Gray.

THE statement by Pilsbry, and quoted by Suter, that the "genus *Eudoxochiton* is sundered by lack of eyes in the valves &c." requires revision. These organs do exist in the genus, and although not so highly developed as in *Onithochiton,* where they are visible to the naked eye, the ocelli in *Eudoxochiton* are quite as advanced as in some of its congeners and therefore merit full recognition.

The eyes are oval in shape, projecting slightly above the general surface of the tegmentum, very minute, rounded at the upper end which is directed towards the apex of the valve, and tapering, goblet-fashion, towards the outer margin. They are arranged in quincuncial formation, and are present upon the lateral areas of the median valves, on the whole surface of the head valve, and on the post-mucronal area of the tail-valve. The eyes are more fully developed on the head-valve than are those of the intermediate valves. In the latter situation they appear usually as mere aggregations of blackish granular matter, but their position and regular arrangement, simulating those of *Levicoplax* and *Icoplax,* render their identification beyond dispute. On the head-valve each eye is accompanied by a single megalopore, which is seen in close proximity to its upper pole, a small canal connecting the two organs; and it is a significant fact that there are no megalopores found in any of the ocelliferous regions otherwise than in this same relationship. The micropores are very numerous, and are found strung along fine parallel lines which lie between the minute riblets composing the microscopic sculpture of all the valves of this genus (Fig. 1).

As Moseley observes: "The eyes are obviously homologous with the megalaesthetes, and as a comparatively late modification, some of the megalaesthetes have been modified into eyes in certain genera, whilst in chiton and other forms, the more primitive conditions, in which they all remain as organs of touch, has been retained."

It is certainly probable that the function of the micraesthetes is tactile, or rather that they constitute the means whereby the animal is sensitive to changes of temperature in the water, as indicated by the emergence of certain loricates during hot weather from the laminarian to the litoral zone. It is equally reasonable to assume that the megalaesthetes possess some degree of visual power even in the most primitive form in some genera, otherwise it is impossible to account for the fact that essentially non-ocelliferous loricates such as *Lepidopleurus* and *Ischnochiton* invariably avoid a strong light.

Note on the Sculpture of *Eudoxochiton nobilis* Gray and *E. huttoni* Pilsbry (Fig. 2).

Sculptured pits upon the valves of these species, hitherto unrecorded, have been observed by Mr. A. E. Brookes and the writer. They are triangular in shape and situated in the central areas, imme-

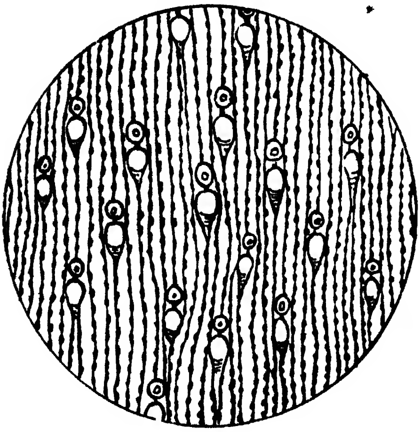


Fig. 1

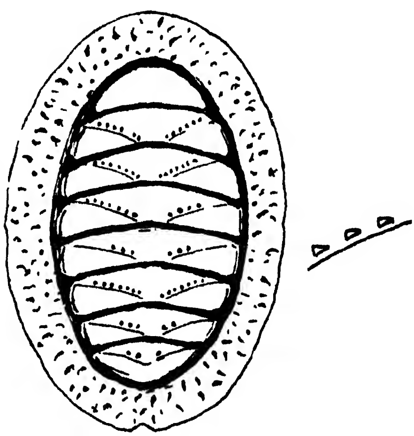


Fig. 2

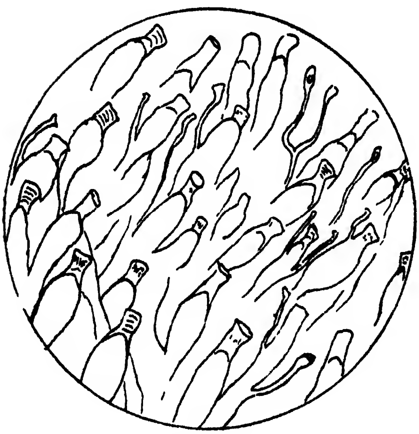


Fig. 3

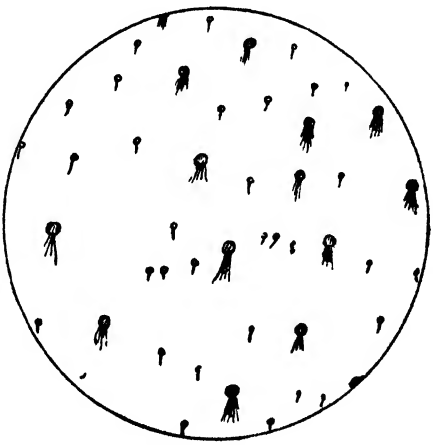


Fig. 4

Fig. 1.—*Eudoxochiton nobilis* Gray. Ocelli with megalopores and micropores. × 230.

Fig. 2.—*Eudoxochiton huttoni* Pilsbry. 80 mm. × 47 mm. Showing sculptured pits.

Fig. 3.—*Pseudotonicia cuneata* Suter. Megalaesthetes and Micraesthetes. Decalcified and stained. × 230.

Fig. 4.—*Pseudotonicia cuneata* Suter. Megalopores and Micropores. Stained Methylene blue. × 230.

diately anterior and parallel to the diagonal line, equally spaced and occurring on all the valves with the exception of the head valve. Frequently they are absent, but when present are rarely the same in number on both sides. Thirty specimens in all were examined, and in seventeen the pits were present. The remaining specimns, though for the most part free from lithothamnia, showed no trace of pitting, while in the entire series none was discovered upon the head-valve of any single specimen. Similar pits are sometimes present in *Levicoplax platessa* Gould, and always in *Icoplax empleurus* Hutton, which latter become shorter and shallower towards the median part of the valve. In *Eudoxochiton* they tend to become obsolete towards the margin, but their character indicates a marked affinity to *Levicoplax* and *Icoplax,* which taken together with the presence of eyes in all three genera, further confirms their generic relationship in the family Lepidochitonidae.

Diagnosis of nerve-terminals in the valves of *Pseudotonicia cuneata* Suter (Figs. 3 and 4).

Suter in his description of this species, states that in all the valves the whole surface is dotted or covered with minute eyes, though in the appended remarks he acknowledges that he might be mistaken as to the identity of these organs. Nor has this uncertainty been dispelled by Ashby in his recent paper "The Rediscovery of *Tonicia* &c." (*Trans. N.Z. Inst.,* vol. 58, 1927, p. 392 *et seq.*). The universal distribution alone of these organs should have suggested a more careful scrutiny, for it had already been pointed out by Moseley that the ocelliferous regions of the valves in loricates are in definite relation to the incisurae. Unfortunately Suter had only one specimen of this rare species at his disposal; but having myself the singular good fortune to collect ten specimens at Mount Maunganui, ample material has been available for an extensive examination.

The best method of demonstrating the nature of these sensory organs is to grind away the under-surface of a valve until sufficiently thin to be translucent, and to stain for one minute in an aqueous solution of methylene blue. Examined under the microscope by transmitted light and using a ⅔ inch objective, the dots will be found to have distinctly taken up the stain. They are megalopores and micropores. The former are circular in outline and well defined, showing a smudge of stain like the tail of a comet, where the dye has penetrated into the capsule of the organ, the colour fading away in the depth of the tegmentum. The micropores, much smaller in size, are also circular in outline; the stain injecting the pore shows the minute neural canal for a short distance as a fine tapering thread. Viewed by reflected light the nerve-terminals appear as refractile convex dots, suggestive of ocelli to the casual observer. The great advantage of employing a staining reagent lies in the fact that the true eyes, such as are present in *Onithochiton, Schizochiton* and *Eudoxochiton* do not stain, the cornea being an impervious hyaline calcareous structure, whereas the easily identified megalopores and micropores in these genera always stain quite readily. Further details of these organs may be studied by decalcifying the shell in a 4% solution of nitric acid, as recommended by Moseley, and shaving

off a thin horizontal section of the tegmentum. When stained with methylene blue, the true nature can be determined with a ⅜ inch objective. The megalaesthetes are elongated fusiform bodies produced at the distal end as a short obconic tube, which is closed at the upper extremity with a flattened circular disc. Beneath this disc is a small zone of fine granular matter or in some instances a few fine transverse lines. Many of the micraesthetes can be observed springing from the dilated bodies of the megalaesthetes, some singly, some branching in pairs from the same stem, while others again have independent fibres of their own which can be traced to the neural plexus lying in the plane between the articulamentum and the tegmentum. Though the micraesthetes often appear as small club-shaped bodies with a nucleus, the fully-developed organs have a flattened disc at the extremity, the whole resembling the seed-capsule of the common poppy.

Pseudotonicia cuneata has been obtained in Tauranga Harbour at depths varying from three to four fathoms; but one has been found on a small stone during warm weather late in the summer, immediately below low-water mark; another crawling half-submerged in wet sand at the same season; and three others upon one rock half buried in sand, also in the litoral zone. This rather singular choice of station militates against the idea of these animals possessing any marked degree of vision, but tends at the same time to strengthen the assumption that the sensory organs are associated with the perception of heat and cold.

Judging from the asymmetry of the head-valve photographed by Ashby as a plesiotype of the species, there is little doubt but that the specimen selected was abnormal, which is satisfactorily proved by the three specimens subsequently secured by Brookes, and all of the ten collected by the writer, possessing five slits in the head-valve and five corresponding radial ribs, arranged in perfect symmetry. This slitting of the head-valve and the total absence of eyes finally disposes of any necessity for the proposed subfamily of Pseudotonicinae.

LITERATURE CITED.

Suter, H. *Manual of New Zealand Mollusca*, 1913.

Moseley, H. N. "On the Presence of Eyes in the Shells of certain *Chitonidae* and on the Structure of these Organs." *Quart. Journ. Micr. Soc.* Lond., vol. 25, 1885.

Ashby, E. "The Rediscovery of Tonicia," *Trans. N.Z. Inst.*, vol. 58, 1927.

The Recent and Tertiary Cassids of New Zealand and a Study in Hybridization.

By A. W. B. POWELL.

[*Read before the Auckland Institute, 31st July, 1928; received by Editor, 28th August, 1928; issued separately, 23rd November, 1928.*]

PLATES 74-76.

THE Cassids are undoubtedly one of the most handsome and conspicuous molluscan groups in tropical and temperate seas. They are also fairly numerous as fossils, ranging throughout the Tertiary.

Three major divisions in the family *Cassididae* are recognized by most systematists and are characterized as follows:—

(1) *Cassis* series.
 Very large heavy shell; long narrow denticulate aperture; short spire; strongly recurved short canal.

(2) *Galeodea* series.
 Moderately large shell; narrowly open aperture, denticulate outer lip; moderately elevated spire; long recurved canal.

(3) *Phalium* series.
 Moderately large shell; widely open aperture; smooth or weakly denticulate outer lip; moderately elevated spire; very short recurved deeply notched canal.

Cassis.

This is a common living type in tropical seas but is rather rare fossil. It is considered younger geologically than either *Galeodea* or *Phalium* (Schenck, p. 74). *Phalium* of Schenck however includes *Semicassis, Casmaria,* and *Doliocassis.* Schenck (*l.c.*) has recorded typical *Cassis* from the West Coast of North America with a range from Lower Pliocene to Recent. Dall (1909, p. 60), however, stated that the earliest true *Cassis* from the European Tertiary was *Cassis mammilaris* Grateloup (Lower Oligocene), while Schenck cited *C. sulcifera* Sowerby as the earliest American form (Oligocene) and mentioned an Eocene example in Cossman's *C.* (*Marionella*) *cheval-lieri* from the Paris Basin.

True *Cassis* is not represented in either the Recent or Tertiary New Zealand faunas.

Galeodea.

Galeodea is considered (Schenck, p. 81) one of the earliest known representatives of the family, ranging from Cretaceous to Recent. It apparently reached its greatest development in the Eocene, but a few Recent species still persist. The genotype, *G. echinophora* (Linné) is a common Recent shell in the Mediterranean.

Galeodea is represented in the New Zealand Tertiary by Hutton's *Galeodea senex* and undescribed species.

Phalium.

Schenck (p. 72) admitted *Phalium* generic rank with *Cassidea* (= *Casmaria*), *Bezoardica* (= *Semicassis*) and *Doliocassis* as subgenera.

Iredale (1927), however, gave full generic rank to *Phalium* Link (citing *Cassidea* Swainson as a synonym), *Semicassis* Morch, *Casmaria* H. and A. Adams, and proposed the following new genera.

Xenophalium nov. type *X. hedleyi* nov.

Xenogalea nov. type *Cassis pyrum* Lamk.

Antephalium nov. type *Cassis semigranosa* Lamk.

Marwick (p. 482) proposed *Kahua* as a subgenus of *Phalium* for an unique Chatham Island Tertiary species.

Finlay (p. 230) proposed *Euspinacassis* for a group of Tertiary *Phalium*-like shells characterized by strong nodulous sculpture.

Semicassis is the most widely distributed of the *Phalium* series and seems to be the oldest geologically, ranging from at least the Oligocene to Recent (Schenck, p. 80). *Semicassis* is represented in New Zealand by a typical species in the Upper Pliocene and one other of the subgenus *Kahua,* from the Mid Tertiary of the Chatham Islands.

Xenophalium, with which the present writer has united *Xenogalea,* is the characteristic Australasian Recent *'Phalium,'* ranging from Miocene to Recent.

Euspinacassis with a range from Oligocene to Miocene is undoubtedly directly ancestral to the late Tertiary and Recent *Xenophalium.*

Typical *Phalium, Casmaria, Doliocassis,* and *Antephalium* are not represented in New Zealand either Recent or fossil.

In the present paper six species are described as new.

The New Zealand Recent Cassid fauna consists of but one genus, *Xenophalium,* represented by eight species and a subspecies, while in the Tertiary there are at least four genera, *Xenophalium* represented by five species, *Euspinacassis* by three, *Semicassis* by two, and *Galeodea* by one described and an undescribed species.

Hutton's *Cassidaria sulcata* (1873, p. 8) from Kanieri (Miocene) is not included on account of the imperfect condition of the holotype, making accurate generic allocation uncertain.

The writer is indebted to the late Dr. J. A. Thomson, and also to Dr. J. Marwick, Mr. H. Hamilton, Mr. W. La Roche, Dr. C. E. R. Bucknill, Miss M. K. Mestayer, Mrs. F. W. Sanderson, and Mr. C. R. Laws for the loan of specimens, and to the following gentlemen for their care and skill with the photography, Mr. H. Hamer (Figs. 13-16, 18, 19, 21-28, 30, 31, 33-36), Dr. C. E. R. Bucknill (Figs. 11, 12, 17, 20), Messrs. Doree and Sache, Ltd. (Fig. 29), and Professor J. A. Bartrum (Fig. 32).

Key to Genera of the Phalium Series.

(1) With one or more varices in addition to outer lip.

A. Columellar callus-plate broad, sculptured with prominent wrinkles. Outer lip strongly denticulate within, sometimes with a few anterior spiny projections. Shoulder plicate or nodulous. False umbilicus widely open.

Phalium Link. Type *B. glacum* Linn.

(2) Minus varices other than outer lip.

A. Columellar callus-plate broad, irregularly plaited and ridged towards pillar. Outer lip with a few faint denticles below. Whole shell covered with spiral rows of prominent nodules and superimposed spiral striae. False umbilicus small.
Euspinacassis Finlay. Type *E. pollens* Finlay.

B. Columellar callus-plate broad, irregularly plaited and ridged all over. Whorls seldom shouldered, mostly sculptured all over with spiral grooves. Outer lip strongly denticulate within. False umbilicus open or almost closed.
Semicassis Morch. Type *Cassis japonica* Reeve.

C. "Shell subglobular, thick, sculpture of strong spiral and axial grooves dividing the surface of the body-whorl on a regularly checquered plan. Outer lip with a strong varix, regularly lirate within. Columella almost straight with six equal cords. Inner lip strongly lirate."
Subgenus *Kahua Marwick* 1928 (p. 482). Type *Phalium* (*Kahua*) *skinneri* Marwick.

D. Columellar callus-plate broad, smooth, bordered below by one or two prominent ridges. Whorls shouldered, nodulous or smooth. Outer lip smooth or faintly denticulate within. False umbilicus open.
Xenophalium Iredale. Type *X. hedleyi* Iredale.

E. Columellar callus-plate smooth, bordered below by several prominent ridges. False umbilicus closed. Basal lip with a few spiny projections as in typical *Phalium*.
Casmaria H. & A. Adams. Type *B. vibex* Linn.

There is a tendency rarely shown in certain individuals of *Euspinacassis* and *Xenophalium* to leave undissolved the variced outer lip preparatory to making another growth stage (Fig. 35). This is probably a recessive character traceable to an ancestral type, normally leaving the varix at each growth stage as in Recent typical *Phalium*.

Species observed exhibiting this feature are:—

Euspinacassis pollens Finlay (holotype).
Xenophalium insperatum (Iredale) 2 Mount Maunganui, N.Z.
X. pyrum (Lam.) 5 Recent N.Z. and 1 Castlecliff (Up. Pliocene) N.Z.
X. labiatum (Perry) 1 Broken Bay, New South Wales, Australia.

Dentition: The radulae of the following species were mounted for study:—

X. pyrum (Lam.).
2. Mount Maunganui, Bay of Plenty.
1. Off Kapiti Island in 25 fath.
1. Off Cuvier Island in 40 fath.

X. hamiltoni nov.
1. Off Cape Campbell in 35-40 fath.

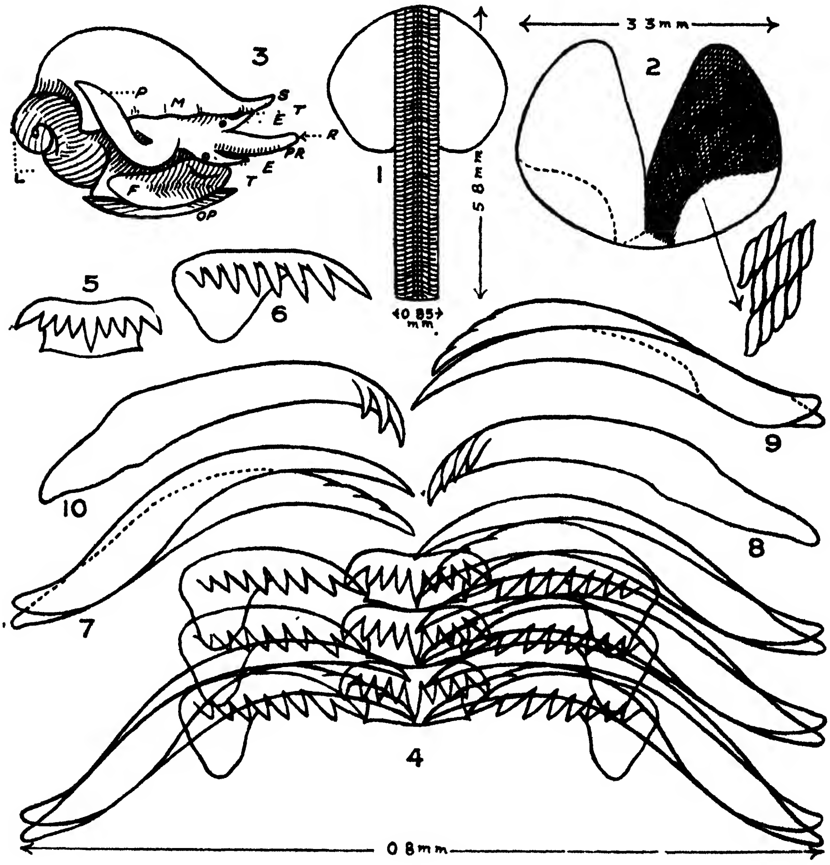
X. insperatum (Iredale).
2. Mount Maunganui, Bay of Plenty.

X. labiatum (Perry).
1. Shell harbour, New South Wales, Australia.

X. labiatum × *inseperatum* (Iredale).
1. Mount Maunganui, Bay of Plenty.

The radula (Fig. 1) is situated behind a pair of jaws (Fig. 2) contained in a long proboscis (Fig. 3 pr.) and is composed of numerous rows of transparent chitinous teeth arranged on a long

transparent ribbon, fitted on either side at the front end with lobes by which it is fixed in position, the rear portion being free. The dimensions of the entire radula in *X. hamiltoni* are 5.8 mm. in length by 0.85 mm. in width, and on it are arranged 102 rows of 7 transverse teeth, making 714 separate teeth, which are also furnished with separate cutting points or cusps to the number of 3,366.



TEXT FIGURES.

FIG. 1.—Entire radula showing lobes by which it is attached (*Xenophalium hamiltoni*).
FIG. 2.—Jaws and plates, greatly magnified (*X. hamiltoni*).
FIG. 3.—External features of animal (*X. pyrum*) about natural size. E, eyes; F, foot; L, liver; M, mantle; OP, operculum; P, penis; PR, proboscis; R, radula; S, siphon; T, tentacles.
FIG. 4.—Three transverse rows from radula of *X. hamiltoni*. Second and third pair of marginals on left not drawn in.
FIG. 5.—Central tooth from radula of *X. hamiltoni*.
FIG. 6.—A lateral tooth from radula of *X. hamiltoni*.
FIG. 7.—Pair of marginals from radula of *X. hamiltoni* (from above).
FIG. 8.—Lower marginal from radula of *X. hamiltoni* (from below).
FIG. 9.—Pair of marginals from radula of *X. insperatum* (from above).
FIG. 10.—Lower marginal from radula of *X. labiatum* (from below).

The formula of the *Cassid* radula is indicated as 2 + 1 + 1 + 1 + 2 meaning that there is a single lateral tooth on either side of a central tooth, then in a plane above a pair of marginals curve over from either side almost meeting at the centre. The upper of the two marginals is plain but the second one, situated immediately below, is furnished with long curved cusps directed downwards. The number of these cusps constitute the main difference between the radulae of the *pyrum* series and *labiatum*. The individual cusps are variable in shape and of little use for classification. The *insperatum* radula differs from that of *pyrum* and *hamiltoni* in the shape of the lower marginals and in the greater number of transverse rows, about 120 in the former as compared with 100 respectively in the latter two.

Formulae of the two types of radulae, the lower figures representing the number of cusps.

(a) $\frac{2}{(0,4)} + \frac{1}{5} + \frac{1}{0} + \frac{1}{8} + \frac{2}{(4,0)}$ = *X. pyrum*, *X. hamiltoni* and *X. insperatum*

(b) $\frac{2}{(0,3)} + \frac{1}{8} + \frac{1}{9} + \frac{1}{8} + \frac{2}{(3,0)}$ = *X. labiatum* and (*X. labiatum* × *insperatum*)

Hybrids: The four main specific characters defining the species *Xenophalium labiatum* and *X. insperatum* are, 1, radula; 2, sculpture; 3, outer lip; and 4, coloration.

In *labiatum* the radula has three cusps on the lower of the two marginals; the whorls are devoid of nodules; the outer lip is thickened and the coloration is dark with orange-tinted columella.

In *insperatum* the radula has four cusps on the lower marginal; the last half-whorl has a nodulous shoulder, the outer lip is thin and recurved, and the coloration is light with white columella.

A striking hybrid between *labiatum* and *insperatum* recently collected by Dr. C. E. R. Bucknill, at Pilot Bay, Tauranga, exhibits the following combination of characters.

1A + 2B + 3A + 4B.

i.e., A = *labiatum* character. B = *insperatum* character.

The numbers refer to specific characters mentioned above.

The shell recently described by Oliver (1926, p. 111) *Calliostoma waikanae* from the New Zealand beach of that name suggests hybridization between the species *cunninghamii* and *pellucidum*. The relative frequency of this suggested hybrid is shown by the following census of the three forms recently collected by the writer at Waikanae: *cunninghamii* 12, *waikanae* 4, *pellucidum* 1.

The writer has previously recorded an apparent hybrid from New Zealand waters in *Verconella adusta* × *adusta, mandarinoides* Powell (1927, p. 558).

Experimental hybridization with marine molluscs presents many difficulties. It is interesting to note, however, that experiments with terrestial molluscs have been successfully carried out in Florida by Bartsch (1925, p. 222) of the United States National Museum. He successfully established a hybrid colony between *Cerion incanum* and *C. viaregis*. Thirty of the resultant hybrids examined showed great diversity in size, sculpture, and colouring, and the internal anatomy showed even greater diversity and modification.

KEY TO SPECIES OF EUSPINACASSIS.

A. Nodules rather sharp and laterally compressed.
  1. Four spiral rows of upwardly directed nodules on body-whorl, 11-13 nodules on shoulder ..... *pollens.*
  2. Four spiral rows of strong laterally compressed nodules on body-whorl. 8 nodules on shoulder. *muricata.*

B. Nodules blunt and rounded.
  3. Four spiral rows on body-whorl, approximately 16 nodules on shoulder . .. . *multinodosa.*

Euspinacassis pollens Finlay.

1926 *Trans. N.Z. Inst.*, vol. 56, p. 230.

The type locality is Clifden, Southland. Oligocene (Ototaran?). I have a specimen from a cutting in the main road, Awakino Gorge, North Island.

Euspinacassis muricata (Hector).

1877 *Cassis muricata* Hector *Prog. Rep. Geol. Surv. N.Z.*, vol. 9, p. 4.

1915 *Galeodea muricata* (Hector) *N.Z. Geol. Surv. Pal. Bull.*, No. 3, p. 12, Pl. 1, Fig. 6.

Readily distinguished by the spiral rows of prominent laterally-compressed nodules, arranged axially in an oblique plane. These nodules are few in number, only 8 on the shoulder of body-whorl and arranged in four rows, the lower ones less prominent. The whole shell is finely sculptured with dense spiral striae, having a fine spiral thread at about every fourth striation. Fasciole longitudinally striated. Pillar with numerous oblique wrinkles and odd tubercles.

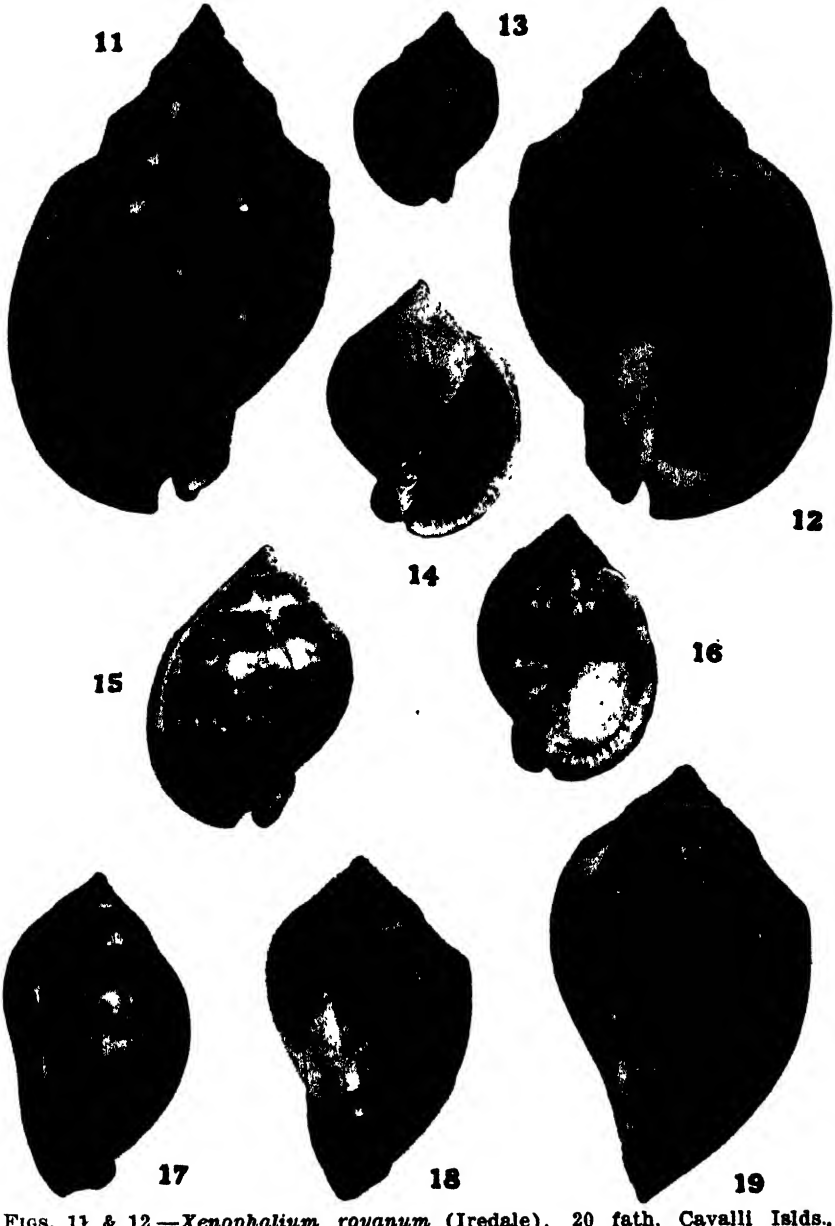
Habitat: Pakaurangi Point (= Komiti Point), Kaipara Harbour. (Oligocene, Hutchinsonian.)

Height, 46 mm.; diameter, 36.5 mm. (specimen in collection of Mr. C. R. Laws, Auckland).

Euspinacassis multinodosa n. sp. (Figs. 30 and 31.)

Shell large, strong, encircled with rows of strong rounded nodules. Outer lip very little thickened, slightly recurved. Canal very short, deeply notched. Whorls 6½, plus minute, dome-shaped, protoconch of 2½ smooth whorls. Spire-whorls angled at centre by a single spiral row of close regularly-spaced rounded nodules. Body-whorl with 4 rows of rounded nodules arranged axially in an oblique plane. First two rows widely spaced, last two close together. The upper row forming the shoulder has approximately 16 nodules on body-whorl as compared with 8 in *muricata,* and 11-13 in *pollens.* The whole shell is crowded with fine spiral lirae, alternating in strength. Spire a little less than half height of aperture.. Suture undulating, just covering an otherwise second row of spire-nodules. Outer lip imperfect in both specimens. Inner lip spreading as a thin callus broadly over parietal wall almost to shoulder.

Columella obliquely flexed, with heavy callus-plate almost closing false umbilical chink. Pillar with several indistinct irregular plaits. Fasciole flattened on top, longitudinally striated.



FIGS. 11 & 12.—*Xenophalium royanum* (Iredale). 20 fath. Cavalli Islds., Whangaroa.
FIG. 13.—*Semicassis multisecta* (Finlay). Kai Iwi (Upper Pliocene).
FIG. 14.—*Semicassis multisecta* (Finlay). Castlecliff (Upper Pliocene).
FIG. 15.—*Xenophalium labiatum* (Perry). The 'Beacon,' Tauranga Harb.
FIG. 16.—*Xenophalium labiatum* (Perry). Smuggler's Bay, Whangarei Heads.
FIG. 17.—*X. labiatum* (Perry)
FIG. 18.—*X. labiatum* × *insperatum* (Iredale)
FIG. 19. *X. insperatum* (Iredale)

Illustrating hybrid, described in this paper. Specimens from Tauranga.

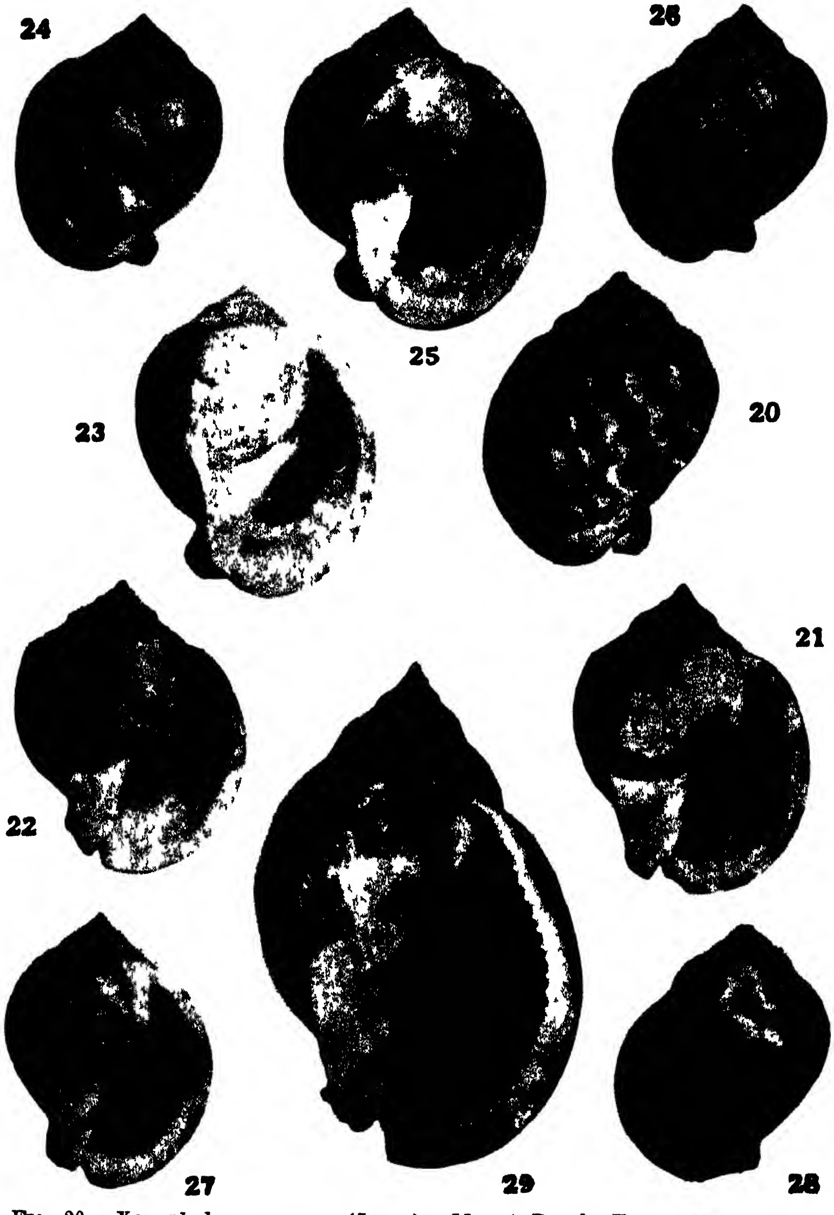


Fig. 20.—*Xenophalium pyrum* (Lam.). Mount Beach, Tauranga.
Fig. 21.—*Xenophalium pyrum* (Lam.). 40 fath. off Cuvier Island.
Fig. 22.—*Xenophalium pyrum* (Lam.). Castlecliff (Upper Pliocene).
Fig. 23.—*Xenophalium pyrum, powelli* (Finlay), 40 fath. Cuvier Id.
Fig. 24.—*Xenophalium pyrum, powelli* (Finlay), off Eastern Coast of Great Barrier Id. in deep water.
Fig. 25.—*Xenophalium hamiltoni* n.sp. (paratype).
Fig. 26.—*Xenophalium hamiltoni* n.sp. (holotype).
Fig. 27.—*Xenophalium harrisonae* n. sp. (holotype).
Fig. 28.—*Xenophalium harrisonae* n. sp. (paratype).
Fig. 29.—*Xenophalium ericanum* n. sp. (holotype).

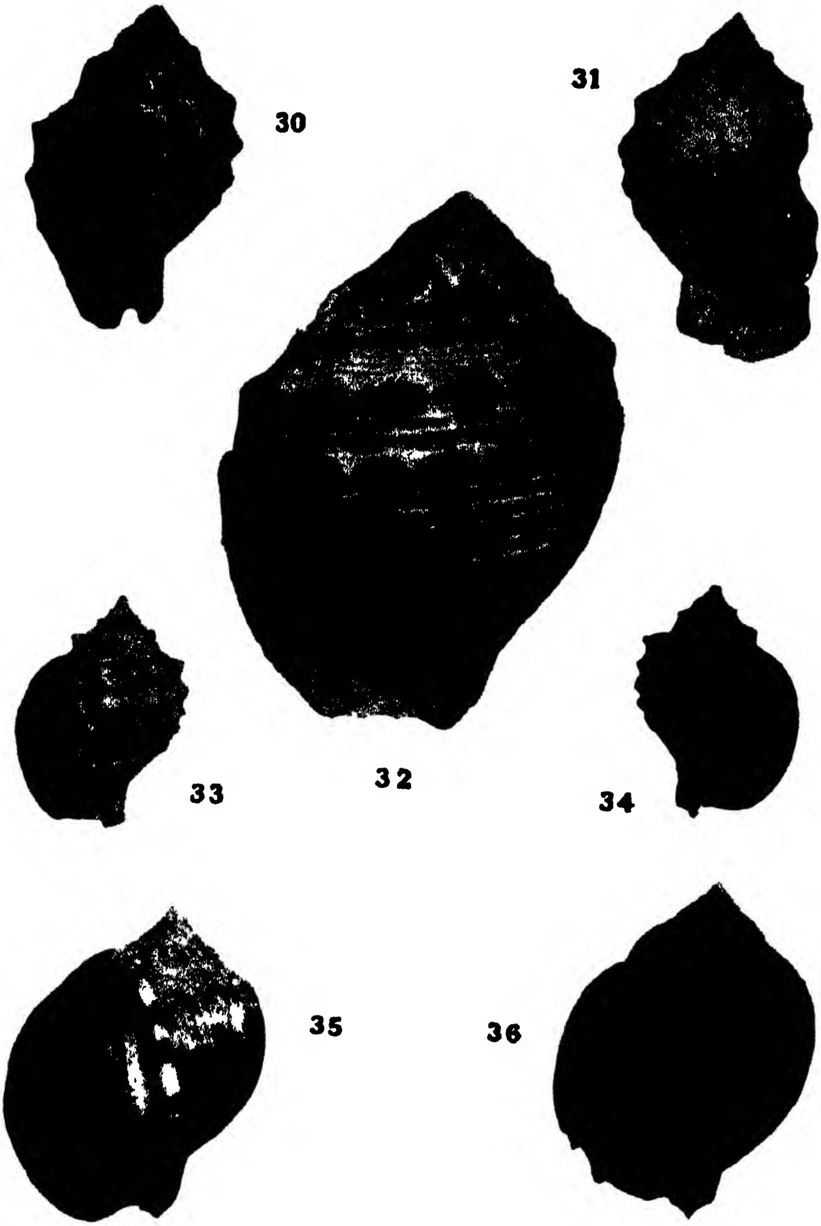


Fig. 30.—*Euspinacassis multinodosa* n. sp. (paratype).
Fig. 31.—*Euspinacassis multinodosa* n. sp. (holotype).
Fig. 32.—*Xenophalium kaawaense* Powell & Bartrum (holotype).
Figs. 33 & 34.—*Xenophalium torcuma* n. sp. (holotype).
Fig. 35.—*Xenophalium pyrum* (Lam.) Tauranga.
Fig. 36.—*Xenophalium wanganuiense* n. sp. (holotype).

Height, 50 mm.; minimum diam., 28 mm. (holotype). (Fig. 31.)
Height, 47 mm.; minimum diam., 27 mm. (paratype).

Holotype and one paratype in writer's collection Auckland.

Habitat: Sea Cliffs at Motutara, West Coast, 30 miles from Auckland in volcanic tuffs, associated with *Parvamussium zitteli* Hutton. (Lower Miocene.) ?

Xenophalium Iredale. Type *X. hedleyi* Iredale.

1927 *Records of Australian Museum*, vol. 15, No. 5, p. 333 = *Xenogalea* Iredale, type *Cassis pyrum* Lam. (*l.c.*, p. 339).

Iredale in defining the first-mentioned genus simply stated that it was characterized by large size and open unarmed mouth. This latter feature is also common to most of the species of his second genus *Xenogalea*, leaving the larger size as the only distinguishing character. This feature alone is hardly sufficient justification for creating a new genus, so the name *Xenogalea* is here considered synonymous with *Xenophalium* which has page priority over the former.

KEY TO THE SPECIES OF XENOPHALIUM

A. Columellar Callus-plate thin to moderately thick, expanded and curved forwards leaving an open false umbilicus

(a) Post-nuclear whorls spirally grooved and strongly nodulous Miocene to Lower Pliocene.

1. Five rows of nodules on body-whorl — *toreuma*
2. Three rows of nodules on body-whorl — *grangei.*
3. Two rows of nodules on body-whorl — *kaawaense.*
4. One row of nodules on body-whorl — *fibratum.*

(b) Spire and base only, more or less spirally grooved. Nodules restricted to shoulder. Outer lip smooth within. Upper Pliocene to Recent.

5. Spire and base spirally grooved. A few indistinct nodules on shoulder of last whorl. Suture rapidly descending on last half-whorl. — *wanganuiense.*
6. Spire nodulous, base striated — *pyrum.*
7. Spire striated, base almost smooth, nodules obsolete .. .. — *pyrum powelli.*
8. Shell globose, spire low, spire and base striated. Suture margined by grooves. Entire absence of nodules. No colour pattern. .. — *hamiltoni.*
9. Spire elevated, striated. Suture margined by grooves, base smooth. Entire absence of nodules. No colour pattern — *finlayi.*

(c) Outer lip denticulate within.

10. Outer lip finely denticulate within. Spire and base deeply grooved. A few inconspicuous nodules sometimes present on body-whorl .. — *harrisonae.*
11. Outer lip strongly denticulate within. Base smooth. Early spire-whorls reticulated. Body-whorl smooth except for axial growth stages and a few sub-sutural spiral threads .. — *ericanum.*

B. Columellar Callus-plate thickened, recurved, enclosing tiny false umbilicus. Recent.

(a) Spire and base smooth. Outer lip denticulate within.

12. Entirely without nodules, outer lip thickened. Columellar-callus tinted buff to orange ... *labiatum.*

13. A few shoulder nodules on body-whorl. Outer lip thin expanded and recurved. Columellar-callus whitish . . .... *insperatum.*

(b) Spire nodulous, base smooth except for a single spiral groove, outer lip smooth within and thickened on outside by rounded varix. Shell very large. Recent.

14. . .. *royanum.*

Xenophalium toreuma n. sp. (Figs. 33 and 34.)

Shell rather small, strong, encircled by rows of strong rounded nodules. Outer lip rather thin, slightly recurved. Canal very short, broad, and deeply notched. Whorls 6½, plus minute dome-shaped protoconch of 2½ smooth whorls. Penultimate whorl with two rows of nodules, the lower one just showing above suture and the upper forming a prominent shoulder just above centre of whorl. Body-whorl with 5 distinct rows of close regularly-spaced rounded nodules and three plain indistinct spiral bands below. The four lower nodulous bands close together, the upper one separated from them by a greater distance. The whole shell covered with exceedingly fine spiral striae, not showing on nodules The shoulder bears 13 nodules on body-whorl. Spire less than half height of aperture. Suture slightly undulating. Outer lip smooth within and slightly recurved. Inner lip spreading as a callus right to shoulder. Columellar-callus rather narrow almost closing false umbilicus. Pillar bordered by a single prominent ridge running right to base of columella. Fasciole smooth, flattened, bordered above by a narrow ridge.

Holotype in author's collection, Auckland.

Height, 34 mm.; diameter, 24 mm.

Habitat: Sea Cliffs at Motutara, West Coast, 30 miles from Auckland in volcanic tuffs, associated with *Parvamussium zitteli* Hutton. (Lower Miocene.) ?

Xenophalium grangei (Marwick).

1926 *Trans. N.Z. Inst.*, vol. 56, p. 319, Pl. 73, Fig. 17.

Type 1135. Tirangi Stream, North Taranaki. (Upper Miocene).

Finlay (1926, p. 230) ascribed *Phalium grangei* Marwick to his genus *Euspinacassis* but the type of scuplture and presence of strong ridge at base of columella suggest closer relationship to the species *fibratum* Marsh. & Murd. and *kaawaense* Powell & Bartrum. *Euspinacassis* is a typical Oligocene type, characterized by strong nodulous sculpture and superimposed dense spiral striae, while the pillar is sculptured with numerous anastomosing ridges. *Xenophalium* on the other hand is a typical Recent type, mostly smooth or with nodules confined to a single row at shoulder. The columella is invariably bordered below by a prominent ridge.

These two extremes are almost bridged by a puzzling series of Miocene and Lower Pliocene shells having prominent nodulous sculpture similar to that of *Euspinacassis* but with a ridged columella as in typical *Xenophalium*. Closer comparison, however, shows that while *Euspinacassis* has secondary sculpture in the form of dense spiral striae continuous over the nodules, the Miocene-Pliocene series have the secondary sculpture confined to the spaces between the spiral series of nodules.

The *grangei-fibratum* series are better placed in *Xenophalium* on account of the great similarity in the form of the columella. Taking the Tertiary species here ascribed to *Xenophalium* in their geological sequence we find a gradual reduction in the number of nodulous rows from five in *toreuma* to one in *fibratum*.

In *Xenophalium* and *Casmaria* the fasciole usually lacks the longitudinal striae whose presence is quite a constant feature in *Phalium, Semicassis,* and *Euspinacassis*. However, as the fasciole of *Xenophalium* is not invariably smooth, no importance can be attached to the presence or absence of this feature in the genus.

There seems no doubt that *Xenophalium* is the evolutionary product of *Euspinacassis* but they are best considered as distinct genera having at least one differentiating character in the form of the columella.

If we admit evolution of species then evolution of genera must also apply. The fact that *Euspinacassis* is extinct and *Xenophalium* now the ruling Australasian Recent Cassid supports this contention.

Xenophalium kaawaense Powell & Bartrum. (Fig. 32.)

1928 *Trans. N.Z. Inst.*, vol. 59, p. 145, Figs. 53 and 54.
Type. Kaawa Creek. (Lower Pliocene).

Xenophalium fibratum (Marshall & Murdoch).

1920 *Trans. N.Z. Inst.*, vol. 52, p. 131, Pl. 8, Figs. 16 and 17.
Type. Waipipi, Taranaki. (Lower Pliocene).

Xenophalium wanganuiense n. sp. (Fig. 36.)

Shell moderately large, ovate, rather thin. Spire and base sculptured with conspicuous linear grooves. A series of indistinct nodules on shoulder of last whorl. Suture rapidly descending on last half-whorl. Columellar callus-plate thick enclosing very small false umbilicus. Outer lip rather thin, rounded, recurved and smooth within.

Height, 64 mm.; diameter, 48 mm.

Holotype and 1 paratype in collection of N.Z. Geological Survey.

Habitat: Wanganui (Upper Pliocene), Castlecliff (type) 2 sp. N.Z. Geol. Surv.; 2 sp. A. W. B. P., Jan. 1927; Kai Iwi. Fragment A. W. B. P., Jan. 1927. Apparently a descendant of the Lower Pliocene *X. fibratum*.

Xenophalium pyrum (Lamarck). (Figs. 20, 21 and 22.)

The type has been localized by Iredale as coming from Southern Tasmania (1927, p. 339). Shells referrable to *pyrum* are also found Recent in shallow water from New South Wales and New Zealand and fossil from the Upper Pliocene of Wanganui, New Zealand. Although no hard and fast differences separate Tasmanian from New Zealand specimens, most of the former have a heavy columellar plate showing a small umbilical cavity, while the predominant New Zealand type has a thin plate directed forwards showing a considerably larger cavity. Even these features however are by no means constant.

It is evident by the occasional occurrence in New Zealand, of the common Australian cassids, *labiatum* and *insperatum*, and the Kermadec Island *royana*, herein recorded, that an effective means of dispersal exists, no doubt by means of pelagic larvae. Divergence between the Tasmanian, New South Wales, and New Zealand colonies of *pyrum* would otherwise be expected but for the assumed fairly regular interchange of larvae by the agency of ocean currents.

The only fossil example I have seen of true *pyrum* is here figured (Fig. 22). It was collected by Mr. W. La Roche recently at Castlecliff, Wanganui, Upper Pliocene, and measures 69 mm. × 52 mm. All other Cassids I have examined from the Wanganui beds have been referrable to either *X. wanganuiense* n. sp., *X harrisonae* n. sp. or *Semicassis multisecta* (Finlay).

The following New Zealand localities for typical *pyrum* are known to the writer.

Mount Maunganui and Opotiki, Bay of Plenty (common). 40 fathoms off Cuvier Island (Fig. 21). Motutara, West Coast (dead shells inhabited by hermit crabs), Paraparaumu and Waikanae Beaches, Cook Strait. (Dominion Museum.) 25 fathoms off Kapiti Island, Cook Strait. (Dominion Museum). Castelcliff, Wanganui. Upper Pliocene (W. La Roche, 1927)

A large thin-shelled form of *pyrum*, with shoulder-nodules and basal spirals obsolete, occurs in deep water around the New Zealand coasts. It cannot be regarded as the normal benthal variant of the shallow water species, as typical *pyrum* also occurs in corresponding depths. It is convenient therefore to regard this form as a subspecies of *pyrum*.

Xenophalium pyrum powelli (Finlay).* (Figs. 23 and 24.)

Shell large, thin, globose. Spire low 1/7 height of shell. Outer lip thin, expanded and recurved, smooth within. Whorls 7½, plus small, globose protoconch of 2½ smooth whorls. Upper spire-whorls finely spirally striated, crossed by faint axial costae. Body-whorl smooth except for indistinct axial growth-lines and very faint indications of basal spirals. Columellar-callus thin, inclined forward, leaving a wide false umbilicus. Colour uniformly pinkish-fawn with irregular axial patches of reddish-brown radiating from suture. Five or six irregular blotches of purplish-brown on outer lip, indicating

*Since this was written Finlay has described this form as a new species. *Xenogalea powelli*, *Trans. N.Z. Inst.*, vol. 59, p. 247, 1928.

the termination of faint colour-bands, only visible on latter part of body-whorl.

Height, 79 mm.; diameter, 66.5 mm. (Specimen in author's collection, Auckland.)

Habitat: Vicinity of Cuvier Island, Bay of Plenty in about 40 fathoms. From local trawler about 1920. Off Eastern Coast of Great Barrier Island in deep water. Mount Maunganui (Ocean Beach) (Dr. C. E. R. Bucknill) and Opotiki (Mr. W. La Roche) cast up alive after gales. Waikanae Beach, Cook Strait (A.W.B.P., 20/12/1927). 40-50 fathoms off Cape Campbell, Marlborough. (Dominion Museum, H. Hamilton, July 1925).

Xenophalium hamiltoni n. sp. (Figs. 25 and 26.)

Shell large, solid, globose, spire low. Spire and base striated and with several deeper grooves immediately below suture. Entire absence of nodules. Whorls 7½, plus small, globose protoconch of 2½ whorls. Columellar-callus thick, inclined forward, leaving a moderately open false umbilicus. Outer lip thin, expanded, recurved, and smooth within. Colour uniformly pinkish-fawn or light-brown with no traces of colour pattern. Interior of aperture, outer lip, columella and parietal callus whitish. Occasional specimens have a few irregular reddish-brown blotches on outer lip.

Height, 71 mm.; diameter, 55 mm. (holotype). (Fig. 26.)

Height, 86.5 mm.; diameter, 66 mm. (largest paratype).

Holotype and 12 paratypes in Dominion Museum, Wellington.

Habitat: Off Cape Campbell, Marlborough, in about 60 fathoms. Collected by Mr. H. Hamilton from S.T. "Futurist," July 1925.

Xenophalium ericanum n. sp. (Fig. 29.)

Shell very large and solid, minus nodules, base smooth. Spire less than ⅓ height of shell. Whorls 7½, including small, globose protoconch of 2½ smooth whorls. First two post-nuclear whorls finely reticulated by flat-topped spiral riblets and slightly retractive narrow axial threads. There are about 14 spirals, the upper four smaller, more closely spaced and marked off from the others by a shallow sub-sutural depression. In the holotype the later whorls are almost smooth except for irregular growth-lines and a few faint spiral threads below suture. In the paratype these growth-lines are much more prominent, particularly above the periphery. Aperture large, ovate. Outer lip strong, thickened, and slightly recurved, with about 23 strong denticles along inner margin. Columellar-callus thick, curving forwards forming an open false umbilicus. Pillar with seven, short strong plications and the usual ridges bordering the base of columellar-callus. Fasciole sculptured with irregular longitudinal striae. Colour pinkish-fawn, mottled with small irregular reddish-brown patches, arranged in obscure spiral series becoming more definite towards outer lip. Five bands on body-whorl.

Height, 108.5 mm.; diameter, 62.5 mm. (holtype).

Height 98.5 mm.; diameter, 62 mm. (paratype).

Holotype in author's collection; paratype in collection of Mrs. F. W. Sanderson, Whangaroa.

Habitat: 25 fathoms off Berghans Head, 8 miles N.E. of Mangonui, May 1928. (Collected by Mr. Eric Sanderson, of Whangaroa, after whom the species is named.)

Remarks: This shell has a slight resemblance to *X. pyrum powelli,* but can be distinguished by the strongly denticulate outer lip and curious axial growth-folds.

Xenophalium harrisonae n. sp. (Figs. 27 and 28.)

Shell large, globose, spire low, very solid. Spire and base deeply grooved. Mostly devoid of axial sculpture except for a few indistinct shoulder--nodules, sometimes present on latter part of body-whorl. Columellar-callus very thick, enclosing small false umbilicus. Columellar slightly oblique; pillar almost straight in outline, sculptured with 8 or 9 transverse ridges, obsolete on reaching callus-plate. The lowest ridge slightly stronger but not prominent and projecting as in *pyrum.* Outer lip thickened inside aperture and with fine denticulate inner edge, outside expanded and recurved. Colour pinkish-fawn, ornamented with small irregular blotches, connected longitudinally in form of flexuous streaks, broken up into four indistinct spiral bands. Fasciole showing usual crescentic transverse growth lines as in *pyrum.*

Height, 66 mm.; diameter, 47 mm. (holotype). (Fig. 27.)

Holotype and 4 paratypes in author's collection, Auckland.

Habitat: Masons Beach, Stewart Island. (Mrs. R. H. Harrison, 1926.) Castlecliff, Wanganui, Upper Pliocene. (N.Z. Geol. Survey coll. 1 sp.).

Xenophalium finlayi (Iredale).

1927 *Xenogalea finlayi* Iredale, *Records of Australian Museum,* vol. 15, No. 5, p. 342.

1924 *Cassidea Stadialis* of Finlay, *Trans. N.Z. Inst.,* vol. 55, p. 525, Pl. 52, Figs. 3, a, b, c.

Shell large and thin, spire elevated. Entire absence of nodules and basal striae. Upper whorls spirally striated. One or two wide, shallow grooves just below suture on lower whorls. Colour uniformly fawn-amber, minus colour pattern.

Habitat: Trawled in about 20 fathoms between Otago Heads and Waikouaiti.

Xenophalium labiatum (Perry). (Figs. 15, 16 and 17.)

Several authentic New Zealand records for this Recent shell are given below. The type locality according to Iredale (1927, p. 347) was probably Sydney, New South Wales. Iredale (*l.c.*) also referred all New Zealand records of *labiatum* to his recently described *insperatum.* True *labiatum* is easily distinguished from *insperatum* by the total absence of shoulder-nodules, buff to orange-tinted columellar-callus and heavy outer lip. *Insperatum* always shows a series of shoulder nodules on the last whorl. The columellar-callus is white and the outer lip is thinner, expanded, and recurved. The New Zealand records for *labiatum,* all carefully checked by the writer, are as follows.

November, 1920. Smugglers Bay, Whangarei Heads (one damaged empty shell, 56 mm. × 36 mm. A.W.B.P.). (Fig. 16.)

November, 1923. The "Beacon," Tauranga Harbour (one specimen found alive in 4 inches of sand between boulders at low spring tide, 61 mm. × 43 mm. Dr. C. E. R. Bucknill). (Figs. 15 and 17.) Tryphena, Great Barrier Island, in about 10 fathoms (two very large specimens obtained from crayfish pots. C. Osborne). Omaha, Hauraki Gulf (one specimen in Auckland University College collection, and two in collection of Auckland Museum labelled as above).

Xenophalium insperatum (Iredale). (Fig. 19.)

1927 *Records of Australian Museum,* vol. 15, p. 349, Pl. 31, Fig. 8.

Type from New South Wales. The distinguishing characters are given above under the species *labiatum.* The New Zealand shells compare well with the original description and the odd New South Wales specimens I have seen.

Winter months, 1922. Mount Maunganui, Bay of Plenty (a number of living specimens cast up on the ocean beach.; largest specimen 73.5 mm. × 51 mm. Dr. C. E. R. Bucknill).

Early summer, 1918. Muriwai Beach, West Coast (one empty shell, A.W.B.P.).

Winter months, 1922. Opotiki, Bay of Plenty (three living specimens cast up with large numbers of *pyrum.* Mr. W. La Roche.).

Since the above was written Finlay has described the New Zealand shell as a new species, *Xenogalea collacea, Trans. N.Z. Inst.,* vol. 59, p. 246, 1928. The present writer is however unable to satisfactorily separate Australian and New Zealand specimens.

Xenophalium royanum (Iredale). (Figs. 11 and 12.)

1912 *Cassidea royana* Iredale, *Pro. Mal. Soc.,* vol. 10, p. 227.

Only two imperfect specimens of this species have hitherto been recorded. Both were from the Kermadec Islands, the type now being in the Canterbury Museum and the other specimen, collected in 1887 by Mr. T. F. Cheeseman, in the Auckland Museum. This latter specimen which is considerably worn and bleached, measures 135 mm. in height by 83 mm. in diameter.

This species is now known to be a definite constituent of the New Zealand fauna, having been collected on several occasions during 1926, in crayfish-pots from 20 fathoms off the Cavalli Islands, Whangaroa, by Mr. E. Sanderson. Five specimens have so far been found, all were inhabited by hermit crabs. The specimen here figured is remarkably well preserved and although much smaller than the type, agrees perfectly in every other detail. The dimensions of the figured specimen and of one of the remaining four, now in the collection of Mr. W. La Roche, of Auckland, are as follows.

Height, 101 mm.; diameter, 61 mm. (Figs. 11 and 12.)
Height, 122 mm.; diameter, 72 mm. (Coll. of Mr. W. La Roche.)

Semicassis multisecta (Finlay). (Figs. 13 and 14.)

1873 *Cassis striatus* Hutton. *Cat. Tert. Moll.*, p. 8.
1914 *Phalium* (*Cassidea*) *achatinum pyrum* (Lamk.) Suter, *N.Z. Geol. Surv. Pal. Bull.*, No. 2, p. 4.
1924 *Cassidea multisecta* Finlay (Nom. Nov.) *Pro. Mal. Soc.*, vol. 16, p. 101.

A rather small solid shell, readily distinguished from the *Xenophalium pyrum* series by the following characters. Shell usually covered all over with regular, prominent, evenly-spaced, spiral linear grooves. Sometimes in large specimens these grooves become faint towards centre of body-whorl. Columellar callus-plate thick, expanded, sculptured with prominent wrinkles and odd tubercles. In adult specimens outer lip thickened, rounded, and strongly denticulate within. Fasciole distinctly, longitudinally striated. Most specimens have a series of blunt quadrangular nodules on the shoulder.

Habitat: Wanganui (Upper Pliocene), Castlecliff 2 sp. A.W.B.P., Jan. 1927 (Fig. 14. 53 mm. × 37 mm.); 1 sp. coll. N.Z. Geol. Survey. Kai Iwi, 2 sp. coll. N.Z. Geol. Survey (Fig. 13, 34 mm. × 23 mm.).

The three main generic characters of *Semicassis*, prominently wrinkled columellar callus-plate, longitudinally-striated fasciole, and crenulated outer lip, make allocation of the species a simple matter. The genus is evidently an old one, having a wide Recent range, although apparently extinct in New Zealand to-day. The nearest geographical Recent occurrence of the genus to New Zealand is represented by the New South Wales *S. diuturna* Iredale.

Other typical species of *Semicassis* are *Saburon* Adamson and *sulcosa* Born, both Mediterranean, *inflata* Shaw West Indies and *Japonica* Reeve from Japan and the East.

LITERATURE CITED.

Bartsh, Paul, 1925. Breeding experiments with Cerions. *Carnegie Inst. of Washington.* Year Book 24.

Dall, Wm. H., 1909. Miocene of Astoria and Coos Bay, Oregon. *U.S. Geol. Surv. Proof Paper 59.*

Finlay, H. J., 1926. New Shells from New Zealand Tertiary Beds, Part 2. *Trans. N.Z. Inst.*, vol. 56.

Hutton, F. W., 1873. *Catalogue of the Tertiary Mollusca.*

Iredale, Tom, 1927. A Review of Australian Helmet Shells. *Records of the Australian Museum*, vol. 15, No. 5.

Marwick, J., 1928. The Tertiary Mollusca of the Chatham Islands including a Generic Revision of the New Zealand Pectinidae. *Trans. N.Z. Inst.*, vol. 58.

Oliver, W. R. B., 1926. New Zealand Species of *Colliostoma*. *Pro. Mal. Soc.*, vol. 17.

Powell, A. W. B., 1927. Variation of the Molluscan Genus *Verconella* with descriptions of New Recent Species. *Trans. N.Z. Inst.*, vol. 57.

Suter, H., 1915. Revision of the Tertiary Mollusca of New Zealand. *N.Z. Geol. Surv. Pal. Bull.*, No. 3.

Schenck, Hubert G., 1926. Cassididae of Western America. *Bull. Dept. Geol. Sci. University of California*, vol. 16, No. 4, pp. 69-98.

Further Notes on an Artificial *Rubus*. Hybrid (× *Rubus parvicoloratus* Vida).

By H. H. ALLAN.

[*Read before the Philosophical Institute of Canterbury, 1st August, 1928; received by Editor, 20th September, 1928; issued separately, 30th November, 1928.*]

PLATE 77.

A DESCRIPTION of the F1 seedlings of this artificial hybrid was given in *Trans. N.Z. Inst.*, vol. 58, 1927, pp. 51-54. The horticultural value of the hybrid was stated in *The Gardeners' Chronicle* of 19th November, 1927, p. 405, and its points of difference from the well-known × *R. Barkeri* mentioned. Reference was there also made to the wild hybrid plant (× *R. Mackayi*) discovered near Notown by Dr. W. Mackay, of Greymouth. This latter plant resembles × *R. Barkeri* rather closely. A third wild hybrid plant was grown for some time on the Nelson Rock Garden Society's rockery. A cutting from this has been established by Dr. L. Cockayne in his garden at Ngaio. The original plant possibly came from the Styx valley, but I have been unable to obtain exact information. This hybrid very closely resembles my artificial one. Should its origin from a wild hybrid plant be definitely shown I propose for it the name × *R. Hollowayi*, after Dr. J. E. Holloway, whose botanical work on the west coast of South Island is so well known.

A comparison of the three wild hybrids with the artificial hybrid strongly suggests that both × *R. Barkeri* and × *R. Mackayi* are derivatives of the cross *R. australis* × *parvus*, and that × *R. Hollowayi* is derived from *R. parvus* × *schmidelioides*. The male parent of my hybrid was *R. schmidelioides* var. *coloratus*. This jordanon I regard as so distinct from what has been considered *R. schmidelioides* proper that it should have specific rank. It is by no means certain, however, that var. *coloratus* is not really Cunningham's *R. schmidelioides*. His description (*Ann. Nat. Hist.*, vol. 3, 1839, p. 568) includes "foliolis omnino ternatis rugosis venosis subtus (discoloribus) valde ferrugineo-tomentosis." This certainly does not fit the jordanon with orbicular-ovate, glabrous leaves.

A comparative table of the vegetative characters of the adult hybrid and its parents is here given, as it may be a long wait till the hybrid plants flower. It is of interest to note that the succession of leaves on lateral branchlets of the adult is from unifoliate, through irregularly bifoliate and trifoliate forms, to the fully trifoliate leaves of the final stage, thus recalling the forms passed through by the seedling plants as a whole.

Characters	*R. schmidelioides* var. *coloratus* (plant used as ♂ parent).	× *R. parvicoloratus* Vida.	*R. parvus* (plant used as ♀ parent).
Growth-form	large scrambling liane	shrub, with stems prostrate and non-rooting	shrub. with far-creeping and rooting stems
Young branchlets	pubescent; prickles numerous; brownish green in winter	glabrous or nearly so; no prickles; golden brown in winter	glabrous; no prickles; chestnut brown in winter.
Leaves: nature	predominately 3-foliate	3-foliate	simple
size	central lflt ± 2.5 cm. by 5 cm.	central lflt ± 1.5 cm. by 6 cm.	± 1.75 cm. by 8 cm.
shape	central lflt ovate-oblong, acute	central lflt linear - lanceolate, acute	linear-lanceolate, acute
petioles	pubescent, prickly	with few hairs, prickly	with very few hairs, not prickly
upper surfaces	somewhat rugose; with scattered hairs	not rugose; glabrous or nearly so	not rugose; glabrous or nearly so.
lower surfaces	whitish, tomentose	pale green, glabrous	pale green, glabrous
margins	coarsely and irregularly toothed, teeth blunt	serrate-dentate, somewhat irregularly, teeth sharp	regularly and sharply dentate.

FIG. 1.

Left.—*R. schmidelioides* var *coloratus*. ♂ parent.
Right.—*R. parvus*. ♀ parent.
Between.—× *R. parvicoloratus* Vida.

The Male Genitalia of the New Zealand Pterophoridae.

By ALFRED PHILPOTT, Hon. Research Student in Lepidoptera, Cawthron Institute, Nelson.

[*Read before the Nelson Philosophical Society, 29th August, 1928; received by Editor, 18th September, 1928; issued separately, 30th November, 1928.*]

ABOUT 20 New Zealand species of this family have been recorded, two or three of which are of doubtful validity. All are endemic except the practically cosmopolitan *Stenoptilia zophodactyla* Dup.; no endemic genus, however, has been evolved.

The most striking characteristics of the male genitalia are the complete absence of all trace of the gnathos and socii, the lateral position on the aedeagus for the entrance of the ductus ejaculatorius (not in *Alucita*) and the peculiar form of the juxta. Not having as yet studied the other Pyraloid families, I am unable to say if the absence of the gnathos and socii is of any phylogenetic significance, but I note that Petersen (Die Gattung Crambus F. *Verhand, 111, Internat. Ento-Kongres. Zurich,* p. 405) figures a well-developed gnathos (which he terms the "subscaphium") in *Crambus.*

The genera *Platyptilia* and *Stenoptilia* have long been recognized by systematists as groups which are not separable by definite and unfailing characters. Though the bulk of the species can be assigned to the separate categories without much difficulty there remain a fair number of forms which fit about equally well into either genus. The male genitalia offer no help in this connection; it is not possible to distinguish the structures generically, and one description may be used to cover the united groups.

Platyptilia Hübner.
Stenoptilia Hübner. (Figs. 1-8.)

These genera are practically cosmopolitan. *Platyptilia* contains by far the greater number of species though *Stenoptilia* would appear (owing to the absence of the black scales in the fringes of the hindwings) to be the more primitive. The two genera comprise all except four of the known New Zealand Pterophoridae, but only eight species have been available for dissection.

Tegumen short, broad, not fused with vinculum; uncus long, narrow, pointed, curved or bent, with short backwardly-directed hairs on upper surface. Aedeagus strongly curved, rather swollen basally, the ductus ejaculatorius entering this swollen portion on the left side; just above this swollen portion is a thumb-like process projecting ventrally and coming into contact with the basal groove of the juxta, while the apical portion of the aedeagus rests between its upper lobes. Juxta forming a curved somewhat funnel-shaped structure at base, with a pair of broad lobes above, and ending in another pair of lobes which are more or less triangular and pointed; both

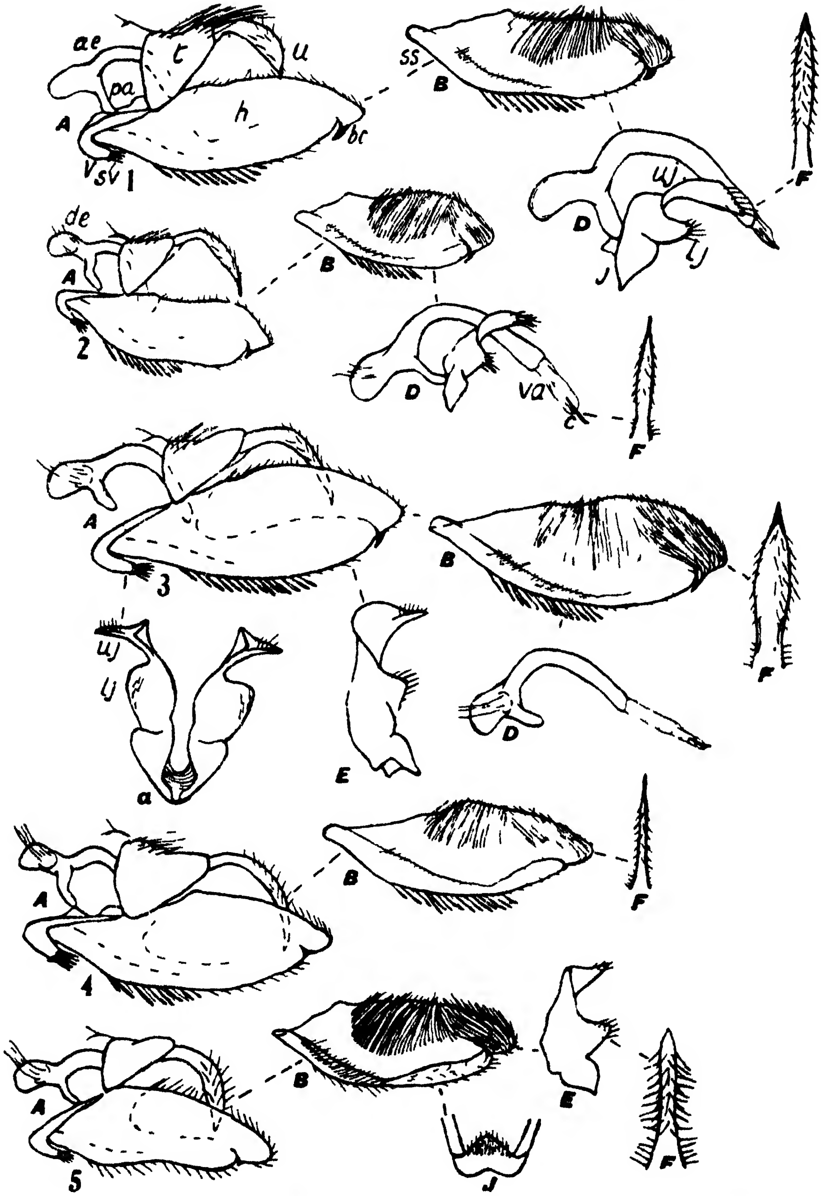


FIG. 1.—*Platyptilia epotis* Meyr. A, male genitalia, B, harpe; D, aedeagus and juxta, F, uncus, dorsal view.
FIG. 2.—*P. aeolodes* Meyr. A, male genitalia; B, harpe, D, aedeagus and juxta; F, uncus, dorsal view.
FIG. 3.—*P. falcatalis* Walk. A, male genitalia; B, harpe; D, aedeagus; E, juxta, lateral view; Ea, juxta, caudal view; F, uncus, dorsal view.
FIG. 4.—*P. deprivatalis* Walk. A, male genitalia; B, harpe; F, uncus, dorsal view.
FIG. 5.—*P. heliastis* Meyr. A, male genitalia; B, harpe; E, juxta, lateral view; F, uncus, dorsal view, J, vinculum.

pairs of lobes bear some short stiff hairs apically and the aedeagus rests between the divergent upper pair. Harpes long, leaf-like; sacculus well marked but not free at apex; cucullus with short ventral hook near apex; central area with dense fine long hair directed towards upper margin, apical hair directed backwards, hair on sacculus basally directed inwards, very short apically. Vinculum with very thin arms; saccus absent, but a rounded process is directed caudally, its apex being covered with short, stout spines.

KEY TO THE SPECIES OF *PLATYPTILIA* AND *STENOPTILIA*

1	With black scales in dorsal fringes of hindwings	2.
	Without black scales in fringes of hindwings*	6.
2	Uncus constricted basally	3.
	Uncus not constricted basally	5.
3	Uncus strongly compressed laterally	*P. epotis* Meyr.
	Uncus not compressed laterally	4.
4	Uncus on dorsal view hardly dilated, juxta with apical lobes blunt-pointed	*P. aeolodes* Meyr.
	Uncus on dorsal view moderately dilated, juxta with apical lobes acutely pointed	*P. falcatalis* Walk.
5	Uncus very thin, long, with finely tapered apex	*P. deprivatalis* Walk.
	Uncus moderately broad, short, apex shortly pointed	*P. heliastis* Meyr.
6	Uncus constricted at base	7.
	Uncus not constricted at base	*S. celidota* Meyr.
7	Uncus almost rectangularly bent	*S. vigens* Feld.
	Uncus very obtusely angled	*S. lithoxesta* Meyr.

*A few black scales are frequently present in *vigens*, also in *lithoxesta*, and, according to Mr. Hudson, in *celidota*. On the other hand, examples of *deprivatalis* are not uncommon in which the scaling is entirely absent.

Alucita Linné. (Figs. 9-12.)

A genus of moderate extent with four endemic species in New Zealand. The male genitalia are more or less asymetrical and differ widely from the type met with in *Platyptilia* and *Stenoptilia*.

Tegumen moderate or broad; uncus curved or recurved, narrow. Aedeagus thin, curved or bent, without ventral process, apex frequently somewhat dilated and bent. Juxta an asymetrical structure with basal plate strongly attached to right harpe and apical portion dividing into a pair of irregular lobes, the left being much the longer. Harpes long, moderate or narrow, curved, more or less asymetrical; sacculus a long thin curved or sinuate free process, sometimes divided into two asymetrical prongs. Vinculum with caudal process as in *Platyptilia*, without hair or spines.

Lettering: ae, aedeagus; bc, barb or cucullus, c, cornutus; de, ductus ejaculatorius; fs, free lobe of sacculus; h, harpe; j, juxta; lj, lower lobe of juxta; pa, ventral process of aedeagus; sh, modified scales on harpe of *A. innotatalis*; sa, sacculus; sv, spines of vinculum; t, tegumen; u, uncus; uj, upper lobe of juxta; v, vinculum; va, vesica. Unless otherwise stated, the views of the genitalia (A) and aedeagus (D) are from the lateral aspect; those of the harpe (B) are from within.

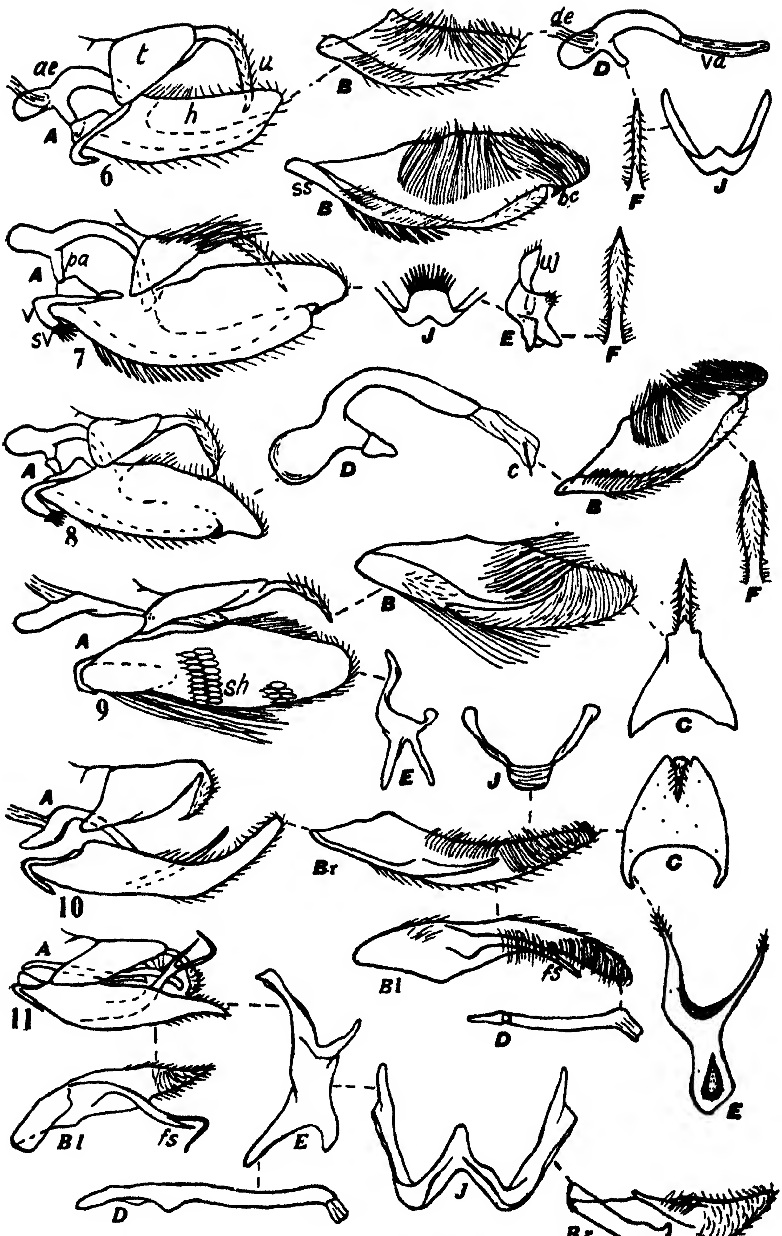


FIG. 6.—*Stenoptilia celidota* Meyr. A, male genitalia; B, harpe; D, aedeagus; F, uncus, dorsal view; J, vinculum.
FIG. 7.—*S. lithoxesta* Meyr. A, male genitalia; B, harpe; E, juxta, lateral view; F, uncus, dorsal view; J, vinculum.
FIG. 8.—*S vigens* Feld. A, male genitalia; B, harpe; D, aedeagus; F, uncus, dorsal view.
FIG. 9.—*Alucita innotatalis* Walk. A, male genitalia; B, harpe; C, tegumen, dorsal view; E, juxta, caudal view.
FIG. 10.—*A. furcatalis* Walk. A, male genitalia; Bl, left harpe; Br, right harpe; C, tegumen, ventral view; D, aedeagus, ventral view; E, juxta, caudal view; J, vinculum.
FIG. 11.—*A. lycosema* Meyr. A, male genitalia; Bl, left harpe; Br, right harpe; D, aedeagus; E, juxta, caudal view; J, vinculum.

KEY TO THE SPECIES OF *ALUCITA*.

1. Harpes covered outwardly, except on apical portion, with large oval scales; uncus slightly curved .... *innotatalis* Walk.
   Harpes without such scales; uncus strongly curved or recurved .... 2.
2. Uncus recurved; sacculus not divided apically .... *furcatalis* Walk.
   Uncus not recurved; sacculus divided apically .... 3.
3. Apex of left harpe narrow, pointed .... *lycosema* Meyr.
   Apex of left harpe moderately broad, rounded .... *monospilalis* Walk.

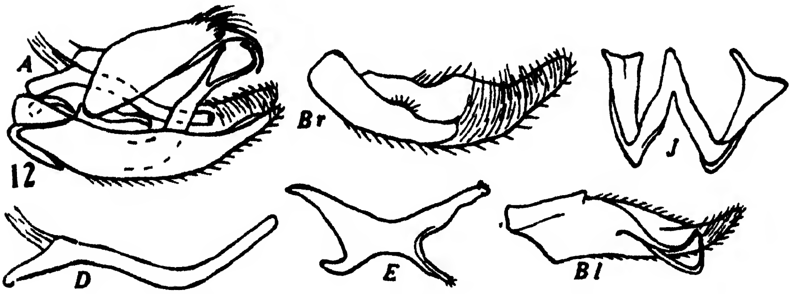


FIG. 12.—*A. monospilalis* Walk. A, male genitalia; Bl, left harpe; Br, right harpe; D, aedeagus; E, juxta, caudal view; J, vinculum.

Mineral Content of Pastures.

Phosphorus Deficiency in some Wairarapa Soils and Pastures.

By B. C. Aston, F.N.Z. Inst.

[*Received by Editor, 1st November, 1928, issued separately, 30th November, 1928.*]

The analyses of a number of soils and pastures from the fertile Wairarapa districts, exhibit such abnormal features that it is desirable to bring the matter prominently before workers in this most important subject for their guidance.

The samples were collected in February 1928, after an exceptionally dry season, only 0.5 of an inch of rain falling in the preceding month of January. Mr. C. M. Wright, Country Analyst, under the Empire Marketing Board's scheme for mineral content of pasture research, collected the samples, and contributes valuable notes on the local conditions prevailing.

Hamua, Hukanui (540 ft. above sea-level), near Eketahuna (soil sample No. x1129, pasture samples 6129, 6130). This farm is situated on rich land, but there were only nine cows, out of thirty-nine, in calf in February. The other thirty cows kept returning to the bull. The day paddocks pasture was six years old and consisted of white clover, cocksfoot, dogstail, ryegrass, and cowgrass, it having had 7½ cwt. superphosphate in three years. The night paddocks were not topdressed, but have been ploughed and are four to six years old. The botanical analysis of the day paddock pasture, 6129, compared with the night paddock, 6130, by weight, on the dry material, is as follows:—

6129 Topdressed		6130 Not topdressed	
	Per Cent		Per Cent.
Cocksfoot and dogstail	34	Cocksfoot	45
White clover	25	White clover	18
Ryegrass	17	Weeds	11
Fog	10	Fog	10
Weeds	4.5	Miscellaneous	16
Red clover	3.5		
Miscellaneous	6.0		

Mr. Webster, Government Veterinarian recently in charge of the Wairarapa District, who is keenly anxious to determine the cause and to find remedies for the various troubles which affect stock, reports that in cows a good deal of temporary and permanent sterility occurred on this farm for the last two seasons, and this season a good deal of abortion took place.

The cowgrass aftermath sample (2024) from paddock was cut for hay in January and not grazed since. This paddock had four cwt. superphosphate on previous crops (swedes and oats). Feeding

cows with linseed nuts and oatmeal increased the yield of milk per cow. The phosphate topdressing has evidently increased the content of phosphate in the pasture here, but the phosphate content is very low in the unmanured paddocks. Clubroot in the swede crop is responsible for failure after the first crop taken. On an adjoining farm, there are only five or six cows, out of fifty, in calf. A pasture sample, No. 6131, showed a higher P_2O_5 content, but this farmer topdresses with phosphate and lime.

Atea, Hukanui. This is poorer country, the forest originally being *Nothofagus* (beech). Last year "Waihi disease" badly affected the cattle, but topdressing a few acres with superphosphate made a great improvement on the poor country, and the clover came away well. This year there has been no "Waihi disease" and it is being further topdressed with phosphates (soil sample No. X 1131). Pasture sample 6132 from the non-topdressed land shows the very low phosphoric acid content of 0.20 per cent. on the dry matter and explains fully why the bone malnutrition disease affected the cows. The lime-requirement of 0.65 per cent. is exceptionally high, and it would probably pay to lime this land if lime is procurable at reasonable cost. Regarding this farm Mr. Webster reports a complete absence of oestrum in a large proportion of the herd.

Hamua rich flat lands contain a farm of 113 acres, carrying 90 cows and about 100 sheep. The river silts this land over each year. Last year there was no temporary sterility in the cows, but this year difficulty is being experienced. The non-topdressed land pasture consists of white clover, ryegrass and crested dogstail. The owner topdressed a small hay paddock of about 8 acres with 2 cwt. superphosphate, and the growth was so strong that he could not deal with it. The original forest was matai, totara, rimu, rata, mahoe, hinau, etc. It is usually understood that matai (black pine) indicates good rich soil. Soil sample x1162 from non-topdressed paddocks. Pasture from non-topdressed land No. 6133. Mr. Webster reports that this farmer has had very little trouble with his stock.

A Mauriceville farm, on land opposite the lime-works, but not topdressed or limed has 40 years' old pasture (sample No. 6128) consisting of white clover, cocksfoot, ryegrass, timothy, and crested dogstail. The cows are clean, but four or five keep returning to the bull. This soil No. x1127, has a slight alkaline reaction, a negative lime-requirement figure and a high lime-content, but the pasture contains only 0.37 per cent. P_2O_5. The well-known effect of calcium carbonate in the soil making the phosphate more available may be economising the small amount of phosphate present in the soil, but the amount present in the pasture is still too low. Mr. Webster reports that this farmer has no trouble, except that an occasional heifer may have difficulty in conceiving.

On some farms between Carterton and Masterton "Waihi disease" appears to have been suspected, as cows were seen chewing bones (soil No. x1139) from Belvedere. Last spring on this farm some 15 acres were top-dressed with superphosphate, 2 cwt. per acre, and bran was fed to the cows. This year the cows have come in season and are holding to the bull. The pasture on the foot-hills

is from country which is growing totara, manuka, and blackberry to some extent. It consists of 75 per cent. of weeds of all sorts, the remainder being bent-grass (Agrostis), brome-grass, white clover, and cocksfoot in about equal proportions, the whole being very old pasture. This pasture (sample 6137) shows a very low nitrogen and phosphoric acid content. Mr. Webster reports this farm to be definitely afflicted with "Waihi disease." Absence of oestrum was also a difficulty, and this farmer has had good results from feeding bran and superphosphate to cows.

From this farm are therefore obtained data which strongly support phosphatic dressing of pasture and supplementary feeding with food stuffs rich in phosphate.

A Featherston farm is about 50 ft. above sea-level, on a rich flat which is annually covered with silt from the Ruamahanga river when in flood. Ground limestone and superphosphate (3 to 1) has been used as a topdressing on the night paddocks, at the rate of 3 cwt. per acre per annum. This pasture is 30 years old and consists of ryegrass 40 per cent., white clover 40 per cent., fog, cocksfoot, and dogstail 20 per cent. It is grazed fairly short, leaving only really good sheep feed (pasture sample 6134. Soil No. X 1133). Mr. Webster reports that this farmer has a fair amount of temporary sterility with typical cervicitis.*

The pasture on the day paddocks was not topdressed, but was the same age as that of the night paddocks and contained white clover 25 per cent., fog 37 per cent., cocksfoot and rye 37 per cent. These were well grazed but not so short as the night paddocks (pasture sample No. 6135, soil sample No. X 1135).

A Greytown farm represents a patch of country where neither willows nor poplars will live, although repeated attempts have been made to establish them. The pasture consists of white clover in good amount, cocksfoot, ryegrass, and fog and is old, possibly 30 years since laid down (pasture sample 6136, soil No. x1137). On this farm there are some special patches of soil representing slight elevations or knobs standing out over the surrounding level, where springs arise and apparently bring to the surface minerals which cause the herbage to be unusually attractive to stock. Sample of soil, x1161, from these knobs shows a high lime-content, but as the sample is a humus one its comparison with the other soils is scarcely permissible (pasture sample 6176). Mr. Webster reports that this farmer has had a considerable amount of sterility, both temporary and permanent, for several years.

This farm was visited by Mr. Grimmett in September last, who learned that the owner had been feeding concentrates, bone-meal, and superphosphate to his cows, but was now relying on topdressing

*The above are Mr. Wright's figures from mere inspection and visual estimate of amount of pasture components present. A botanical analysis made in the laboratory shows the estimate to be a very close one, the figures obtained being:

Grasses	55.3	per cent.
Legumes	42.3	" "
Weeds	2.3	" "
	99.9	" "

the pasture with lime and superphosphate. The September pasture sample showed 0.79 per cent. phosphoric acid and 0.65 per cent. calcic oxide (pasture sample No. 6176).

A Kaituna farm situated on the foot-hills near Mt. Holdsworth at an altitude 650 ft. above the sea represents a large area of country. The forest was originally of the tawa-rimu type with totara scattered through it. Topdressing with superphosphates makes a great difference in the apparent palatableness of the pasture and the clover content. The area not topdressed was neglected, while that topdressed was well grazed and about five times richer in clover. Last season the cows did not come into season until after Christmas, but this season they were fed with bran and superphosphates from the end of September to the end of December and now (February) seem normal. The twenty-five year old pasture consists of browntop, white clover, dogstail, fog, Danthonia, fescue, and weeds (pasture No. 6126). The farm was visited again in September and a further sample of the pasture collected (6175). It will be seen that the February sample contained only 0.2 per cent. phosphoric acid, whereas the September sample contained 0.45 per cent. Clubroot in swedes is reported from this locality. The owner was unfortunately absent at the second visit and the samples are not necessarily from land treated similarly. Mr. Webster reports that this farmer has experienced a good deal of " Waihi disease " and absence of oestrum until late in the season.

Several farms were visited in September in the Featherston district, and samples of pasture taken from farms where temporary sterility and eclampsia were either occurring or had occurred. The pastures generally were of a high order of nutritive value, consisting of ryegrass, clovers, cocksfoot, and fog. Some of the farms had been dairied on for 60 years and had had no fertilizer until the last few years. Pasture samples 6172, 6173, and 6174 all showed a high phosphate-content compared with previous samples taken in February, about 1.1 per cent. P_2O_5 and with 0.53 to 0.79 per cent. CaO. It does not appear that a deficiency of either phosphoric acid or lime is present.

THE SOIL.

Mechanical Analysis: The soils and sub-soils have been analyzed by the most recent method, i.e., the dispersion method of the Agricultural Education Association (of England). The results are given in the table 1. They show that the soils of the Wairarapa range from loams to sandy and silt loams. There is also a small proportion of soil resulting from the drainage of swamp-lands which are so high in their organic matter content as to be classified as humus, or peaty soils, which must always be considered as a class apart, and not to be judged by standards in use for ordinary soils. Loam-soils are usually highly fertile, and no exception can be taken to the texture of the Wairarapa soils, when viewed in the light of their mechanical composition.

Chemical Analysis: The top soils (9 inches) have been analyzed chemically (see table 2), and show rather a wide range in reference to the need for lime. Of the non-humus soils only one shows

an unusually high lime-requirement figure, the Hukanui soil which requires 0.65 per cent. of carbonate of lime, another soil near the Mauriceville lime-works has a negative requirement and a slight alkaline reaction. The fact that the clovers are so prominent a feature in the pastures shows that there is no lack of calcium in the autumn food-supply, and that from the point of view of the health of stock further calcium applications are not indicated as necessary.

The lime-requirement figures of the samples received from the Wairarapa over a series of years have been examined, and the following results may be of interest.

No. of samples analysed	Locality	Average Lime Requirement, Hutchinson McLellan Method $CaCo_3$
2.	Woodville	0.24 per cent.
3.	Pahiatua	0.29 " "
8.	Eketahuna	0.42 " "
2	Masterton	0.09 " "
6.	Wairarapa South	0.30 " "
8.	Featherston	0.21 " "

There is nothing in these figures to denote such a pressing need for lime in the Wairarapa district that the health of stock is liable to suffer. The results are what one would expect in an ordinary North Island soil where the requirement is usually from 2-4 tons per acre, roughly equivalent to 0.2 to 0.4 per cent. calcic carbonate.

Total nitrogen is present in good proportion, and potash would in no case seem to be deficient. The only other constituent it is necessary to enquire into is the phosphoric acid, and it will at once be seen that on several of the farms the total phosphoric acid is present in low amounts The available phosphoric acid when it falls to such a low figure as 0.003 to 0.005 per cent. is very low, and even 0.007 is low when one has to consider the effects of a droughty summer and that the pasture is for the maintenance of dairy cows as well as sheep. Summing up the results as shown by soil-analysis, one may say that it is quite probable that lime will do good in most cases, but the abundance of the clovers, which usually contain about twice as much calcium as the ordinary grasses, indicate that it is not to the deficiency of calcium in the pasture that one may attribute the failure of cows to thrive normally. In the case of phosphoric acid, there is clearly room for suspicion that owing to the low amount present and the fact that drought occasions a greater diminution in the phosphate absorbtion from the soil by pasture than of the other mineral elements likely to be deficient, it is quite likely that if lack of any mineral food is causing partial sterility or "Waihi disease" in cows, that mineral food is phosphoric acid. The best evidence, however, must be looked for in the analysis of the pasture.

Pasture Analysis: In these samples (see table 3) it will be seen that there is a very great disproportion in the relative amounts of phosphoric acid and calcium oxide present. In the phosphoric acid amounts are found which would compare with what is found in the poor pastures in the Island of Lewis, 0.25 per cent., the Falkland

Islands 0.54 per cent., and the comparatively dry innutritious pastures of South Africa. The very low nutritive value of the pastures in some cases, as shown by the nitrogen determinations, should be noted. Low phosphorus-content appears to occur together with low nitrogen-content. There are no instances of very low iron-content, but a number of the samples are contaminated by soil as shown by the high alumina-content of the pasture-samples.

The manganese-content is below the iron-content in most cases, but some of the manganese and iron may be contributed as a contamination by the soil. The calcium-content is as a rule high for a pasture.

Sir Arnold Theiler in his work on South Africa ("Minimal Mineral Requirements in Cattle," *Journal of Agricultural Science,* July, 1927), carried out very careful experiments with heifers to determine what was the effect of low mineral-rations, particularly regarding phosphorus and calcium, the proportion of the different minerals being varied in different experiments.

As examples of low calcium-rations he quotes:—

"A" experiment where 6.9 grams of CaO were given per day, which may be conveniently referred to as .0150 lb. CaO.

"E" experiment where 8.2 grams of .0183 lb. CaO were given.

As examples of high calcium rations he quotes:—

"D" experiment 29.0 grams CaO per day, or .0650 lb. CaO.

In "E" experiment abundant phosphate was provided for both animals. In this experiment one animal aborted twin calves, the other gave birth to a normal calf, but the cow died of metritis following retention of the afterbirth.

The Wairarapa pastures, assuming that only the lowest summer amount of calcium oxide found (0.7 per cent.) was present, would provide a cow eating 28 lb. of dry matter with 0.196 lb. CaO per day, or more than thrice as much calcium as Theiler considers a high calcium-ration.

Again, Wilson considers that the average cow's rations should contain:—

For maintenance	.016 lb. CaO.
For calf (unborn)	.008 lb. CaO.
For every gallon of milk .	.016 lb. CaO.
	.040 lb. CaO per day,

or more according to yield of milk.

The Wairarapa cows should be getting more than three times this amount of calcium oxide in the pasture, which is lowest in calcium.

Turning to the phosphorus-supply of the Wairarapa cows, there are Theiler's excellent experiments, which are again of great assistance in helping one to form an opinion as to *minimal* requirements. In experiment "D" in which only 5.1 grams P_2O_5=(0.0114 lb.) were

consumed in the ration of each of two heifers, ample other nutrients being provided, it was found that both animals developed "Styfsiekte" (a malnutrition disease affecting the bones) and gave birth to an abnormal or a dead calf respectively. Theiler considers "stytsiekte" is "straight aphosphorosis" (phosphate deficiency disease). The supply of P_2O_5 in this experiment "D" is obviously inadequate. As an adequate P_2O_5 supply "more than sufficient for growth, and indeed, sufficient to obviate actual deficiency disease after calving, provided the milk yield is *low*" Theiler instances in experiment "C" the case of two heifers, which each received in her ration 28 grams (.0625 lb.) P_2O_5. In this experiment the mothers remained healthy and gave birth to healthy calves, which developed normally. In these experiments of Theiler's, which were conducted under South African conditions, it must be remembered that only a maximum of 3½ lb. of hay was given daily to each animal, the most of the ration consisting of concentrates, such as bran, crushed maize preparation "fanko," bone meal, and blood containing phosphoric acid in a high state of availability. No grazing was given, so that the total ration apart from minerals would weigh not more than 13½ lb. daily for each heifer. It is worth noting that Theiler presumes that skeletal reserves (the reserve of P_2O_5 in the bones) are sufficient to allow for comparatively normal growth for several months, a valuable provision of nature enabling large-boned animals to tide over temporary shortages of phosphate in their rations. It is thus seen that 0.0114 lb. P_2O_5 daily for heifers is entirely inadequate, but that under similar conditions 0.0625 lb. P_2O_5 is quite sufficient when the P_2O_5 is given in a highly available form such as bone and bran, and the milk yield is not high. It is to be noted that Theiler's experimental heifers gave only up to 5 litres of milk daily (about 9 pints), or at the outside little more than sufficient for the calf, but an amount which entails a small drain of P_2O_5 on the mother. Thus according to Wilson a cow requires:—

For maintenance	0.018 lb. P_2O_5
For calf (unborn)	0.009 lb. P_2O_5
For each gallon of milk	0.018 lb. P_2O_5
	0.045 lb. P_2O_5

A two-gallon cow would therefore require .063 lb., but some of Theiler's ½-gallon heifers only .036 lb. P_2O_5. On the other hand, the heavier and higher-yielding cows reported on by Woodman would require 0.099 lb. P_2O_5 or nearly one-tenth of a lb. P_2O_5 daily. These are the actual requirements of the animal, and it must always be remembered that only one-half of the phosphoric acid in the dry matter is digestible. The average cow cannot consume more than one hundred-weight of green grass daily. This contains 25 per cent. of dry matter, or 28 lb. Some of the Wairarapa pasture contained as little as 0.2 per cent. of phosphoric acid in the dry matter, which would allow the cow to consume only 0.056 lb. P_2O_5 daily as an outside limit, and if only one-half of this is digestible, and the cow is giving two gallons of milk a day, it is seen that it requires .063 lb. and is only digesting 0.028 lb., so that the milk being unalterable

in composition, the cow must supply the deficiency from her own bones.

Dr. H. E. Woodman, Cambridge, has recently been quoted as saying that a 12 cwt. cow giving 4 gallons of milk daily, will eat 30 lb. dry matter daily as grass and requires 3½ ozs. = (.22 lb.) P_2O_5 in the daily ration, which will come very near to the above figure (.099 lb. P_2O_5) doubled to allow for the half of the phosphate in the feed being indigestible.

In making these calculations as to the requirements of the average dairy cow, it is assumed that she weighs something over 10 cwt., in order to be able to ingest that amount of grass which would correspond to 28 lb. of dry matter. A 12 cwt. cow will, of course, be able to consume more grass, i.e., equivalent to say 30 lb. dry matter, and, on the other hand, a cow weighing less than 10 cwt. will not be capable of dealing with 1 cwt. of grass, and so will be limited in its dry-matter consumption to less than 28 lb. daily.

SUMMARY.

The outstanding deficiency of the poorer Wairarapa lands would appear from the results of samples drawn last summer to be that of phosphoric acid. It was found that the amount of phosphoric acid in the cow pastures might sink to a figure lower than any met with in New Zealand.

The remedy for this state of things is that the topdressing of pastures with superphosphate should be made a matter of urgency by all farmers who value the health of their stock, as deficiency of any element in the food supply, especially one so important to milch cows as P_2O_5, is likely to lead to starvation, lowered vitality, and the predisposition to all diseases to which starvation makes them vulnerable.

Table 1.

Mechanical Analyses.

Results are percentages on air-dried soil.

Laboratory No.	Description of Soil. (Classification of U.S. Dept. of Agriculture, modified.)	Analysis of "Fine Earth" passing 2mm. Sieve.							Loss on Ignition.	Stones and Gravel.	Matter soluble in $\frac{N}{5}$ H.Cl.	
		Fine Gravel.	Coarse Sand.	Fine Sand.	Silt.	Fine Silt.	Clay.	Moisture.				
1125	Loam	0.1	1.8	29.3	18.3	15.6	18.6	3.6	12.7	5.0	1.7	Soil Kaituna.
1126	Loam	0.1	1.5	32.3	18.5	16.5	19.0	3.7	8.7	Nil	1.7	Sub-soil of 1125.
1127	Fine sandy loam	0.2	3.4	36.3	13.5	12.8	14.5	5.6	11.8	5.4	1.9	Soil Mauriceville Lime-works.
1128	Fine sandy loam	0.0	1.3	40.4	19.1	15.9	13.8	2.9	6.8	Nil	1.4	Sub-soil of 1126.
1129	Silt loam	0.0	0.2	17.3	26.0	14.8	12.0	9.1	17.5	1.5	3.9	Soil. Hamua, Hukanui.
1130	Silt loam	0.0	0.1	27.9	31.8	16.8	4.5	7.7	9.5	Nil	3.4	Sub-soil of 1128.
1131	Silt loam	0.1	1.0	15.1	23.3	17.8	17.0	5.0	20.1	4.8	3.4	Soil. Atea, Hukanui.
1132	Silt loam	0.2	1.5	17.6	25.3	18.8	18.5	4.3	13.7	6.3	3.4	Sub-soil of 1131.
1133	Loam	1.2	10.0	17.7	14.5	21.5	18.3	2.7	10.6	4.6	3.0	Soil. Featherston.
1135	Silt loam	0.0	0.2	9.6	20.8	34.0	19.0	3.9	12.3	trace	3.1	Soil. Featherston.
1136	Silt loam	0.0	0.1	8.4	26.0	32.0	16.8	4.1	10.4	trace	2.8	Sub-soil of 1135.
1137	*(See below)	0.0	0.2	2.1	3.3	5.3	21.8	8.2	54.3	28.6	3.7	Soil. Greytown.
1138	*(See below)	0.1	0.3	2.7	4.5	6.5	30.0	8.8	45.2	22.2	3.4	Sub-soil of 1137.
1139	Loam	0.1	1.4	18.1	22.3	19.0	21.8	4.5	13.3	1.8	1.8	Soil. Belvedere.
1140	Loam	0.3	1.6	20.8	24.8	20.8	21.5	3.5	8.6	Nil	2.3	Sub-soil of 1139.
1162	Loam	0.0	1.6	27.7	21.3	19.5	16.5	4.4	9.2	Nil	1.6	Soil. Hamua.
1163	Loam	0.0	0.5	24.3	23.2	22.0	19.0	4.1	7.3	Nil	2.2	Sub-soil of 1162.

*These have too much humus for a classification to be of any use.
The ignited soil is mainly clay.

Analysed by E. B. Davies.

TABLE 2.

CHEMICAL ANALYSES.

Results, except*, are percentages on soil dried at 100° C. Soils taken to a depth of 9 inches.

Laboratory No.	Locality	Volatile Matter		Total Nitrogen.	1% Citric-acid Extract, Dyer's Method, Hall's Modification ("Available Plant Food.")				Hydrochloric acid Extract ("Total Plant Food")				Lime-requirement, % $CaCO_3$.		pH Value.	Remarks.
		* At 100° C.	On Ignition.		Lime, CaO.	Magnesia, MgO.	Potash, K_2O.	Phosphoric Acid, P_2O_5	Lime, CaO	Magnesia, MgO.	Potash, K_2O.	Phosphoric Acid, P_2O_5	On Air-dried Soil.	On Soil dried at 100° C.		
X 1125	Kaituna, Mt. Holdsworth. No topdressing.	3 62	12.66	0·286	0.135	0.027	0.033	0.003	0 32	0 66	0.54	0.02	0.36	0.37	5.3	February (Midsummer) P_2O_5 in pasture 0.20 per cent.
1127	Mauriceville. No topdressing.	5.60	11.82	0.340	1.729	0.029	0.024	0.007	3 24	0.78	0.64	0.02	-0 06	-0.06	7.5	(Calcic Carbonate present) 0.37 per cent.
1129	Hamua. No topdressing.	9 08	17.50	0.545	0.188	0.042	0.049	0.007	0.81	0.78	0.48	0.05	0.40	0.44	6.0	0.29 " "
1131	Hukanui, Atea, Hukanui. No topdressing.	4.96	20.06	0.482	0.134	0.032	0.023	0.005	0.51	0.66	0 35	0.02	0.62	0.65	5.2	0.20 " "
1133	Featherston South (Night paddocks). Topdressed.	2.70	10.58	0.345	0.236	0 044	0.027	0.014	0.74	1.22	1.38	0.08	0.33	0.33	5.6	0.63 " "
1135	Featherston South (Day paddocks). Not topdressed.	3.92	12.26	0.360	0.334	0.055	0.020	0.016	1 17	1 35	1.65	0.04	0.31	0.32	5.7	0.56 " "
1137	Greytown.	8.24	54.28	1 403	0.454	0.139	0.022	0.008	1.13	0.74	1.05	0.10	1.16	1.26	5.2	(Humus soil) 0.44 " "
1139	Belvedere. Not topdressed.	4.46	13 32	0 341	0.124	0.037	0.030	0.005	0.65	0 72	0.58	0.02	0.41	0.42	5.4	0.26 " "
1161	Greytown. Knobs soil.	12.42	57.22	1.595	0.597	0.150	0.022	0.007	1.45	0.61	0.72	0.07	—	—	5.0	(Humus soil)
1162	Hamua. Not topdressed. Richest soil in district.	4.38	9.20	0.291	0.200	0.049	0.023	0.010	0.84	1 12	1.20	0.02	0.21	0.22	5.8	0.56 " "

Soil analyses by F. J. A. Brogan and D. F. Waters.

Table 3.

Wairarapa Pastures Collected in February, 1928.

The results are expressed as percentages on the material dried to constant weight at 105° C. in electric oven.

Laboratory No.	Locality	Ash.	Silica. Crude.	Silica. Pure.	Iron Oxide Fe_2O_3.	Alumina Al_2O_3.	Phosphoric Acid, P_2O_5.	Calcium Oxide (Lime, CaO)	Magnesia MgO.	Manganese Oxide, Mn_3O_4.	Chlorine.	Nitrogen.	Sulphuric Acid, SO_3.	Remarks
6126	Kaituna	7.44	1.75	1.67	0.025	0.081	0.36	1.08	0.43	0.045	0.66	2.13	..	Topdressed with super 4 cwt. in 2 years.
6127	Kaituna	6.96	2.52	2.40	0.022	0.077	0.20	0.89	0.49	0.045	0.54	1.14	...	Not topdressed.
6128	Mauriceville	11.10	3.25	3.07	0.092	0.212	0.37	1.87	...	...	0.87	2.04	0.39	No topdressing.
6129	Hamua	9.59	1.30	1.21	0.036	0.083	0.48	1.48	...	0.030	0.93	2.63	...	Topdressed with 7 cwt. super over 3 years.
6130	Hamua	9.60	1.60	1.53	0.025	0.050	0.29	1.17	0.55	0.028	1.11	2.15	...	Not topdressed.
6131	Hamua	9.31	1.37	1.28	0.043	0.130	0.38	1.48	0.69	0.022	0.84	2.51	...	Topdressed with super and limestone 2½ cwt.
6132	Hukanui	7.41	2.95	2.74	0.056	0.167	0.20	0.86	0.32	0.028	0.40	1.65	...	Farm on which "Waihi Disease" occurred.
6133	Hamua	10.28	2.32	2.15	0.063	0.203	0.56	1.17	0.67	0.041	0.92	2.41	...	Rich soil but not top dressed.
6134	Featherston	10.99	2.74	2.55	0.060	0.180	0.63	1.53	0.72	0.047	1.27	3.34	...	Lime and super topdressing.
6135	Featherston	11.69	3.06	2.93	0.057	0.120	0.60	1.23	0.56	0.038	1.26	3.28	...	No top-dressing.
6136	Greytown	9.26	2.84	2.49	...	..	0.44	0.94	0.66	0.098	1.18	2.45	...	
6137	Belvedere	8.90	2.87	...	0.042	0.135	0.25	1.03	..	0.095	1.01	1.59	0.69	
2024	Hamua	10.02	...	0.22	0.018	0.025	0.56	2.86	.	...	0.22	4.83	...	Pure red clover sample.

Wairarapa General Pastures Collected in September, 1928.

Laboratory No.	Locality	Ash.	Silica. Crude.	Silica. Pure.	Iron Oxide Fe_2O_3.	Alumina Al_2O_3.	Phosphoric Acid, P_2O_5.	Calcium Oxide (Lime, CaO)	Magnesia MgO.	Manganese Oxide, Mn_3O_4.	Chlorine.	Nitrogen.	Sulphuric Acid, SO_3.	Remarks
6172	Featherston	11.26	2.10	1.92	0.065	0.163	1.14	0.79	...	0.026	1.23	5.43	...	From unmanured old flax swamp paddock. Green spring growth.
6173	Featherston South	11.93	2.52	2.26	0.124	0.340	1.16	0.76	0.44	0.023	1.22	5.31	...	From old swamp paddock. 2½ cwt. super in two years per acre topdressing. New lush growth.
6174	Featherston	11.72	2.65	2.43	0.085	0.243	1.14	0.53	0.50	0.029	1.04	5.40	.	Short green feed. New spring growth.
6175	Kaituna	8.91	4.21	4.06	0.040	0.157	0.45	0.60	0.32	0.057	0.51	2.49	...	Little spring growth, taken among logs on hillside foothills.
6176	Greytown	8.74	1.69	1.67	0.014	0.045	0.79	0.54	0.48	0.050	1.27	4.06	...	Rather rank growth among rushes on partly drained swamp.

Analysed by B. C. Aston assisted by cadets Sykes and Thompson.

Magnetic Investigations in New Zealand.

ABSTRACT.

AN important article from the pen of the late Dr. Charles Chree, F.R.S., on the "Value of Magnetic Investigations in New Zealand and Samoa" appears in Vol. 10, No. 2, of the N.Z. Journal of Science and Technology. This article discusses the present position of our knowledge of Terrestrial Magnetism and indicates the great importance of Observations at the places mentioned in throwing light on the questions involved.

—C. C. F.

TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

VOL. 59
(QUARTERLY ISSUE)
Part 4, DECEMBER, 1928

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD OF GOVERNORS OF THE INSTITUTE

ISSUED 28th MARCH, 1929

Wellington, N.Z.
FERGUSON & OSBORN LTD., 202 LAMBTON QUAY.
WHELDON & WESLEY, Ltd., 2, 3, and 4 Arthur Street, New Oxford Street, London, W.C.

CONTENTS.

Part 4, 1928.

BOTANY.

GEOLOGY.

ZOOLOGY.

MISCELLANEOUS.

A Tentative Theory of Frictional Electricity.

By PROFESSOR P. W. BURBIDGE, B.A. (Res.), (Cantab.), M.Sc. (N.Z.)

[*Read before the Auckland Institute, 31st July, 1928; received by Editor, 11th October, 1928; issued separately, 25th March, 1929.*]

As far as is ascertained with any certainty, the following are at present the proved experimental facts relating to the phenomenon traditionally known as frictional electricity:—

(1) Substances rubbed together (when insulated) give opposite charges, in equal amount. One at least of the substances must be an insulator. The substances may be solid and solid, solid and liquid, solid and gas.

(2) Substances may be arranged in a series such that the signs of the charges acquired may be determined by the order in the series. (There is much variation in the orders of such series but each worker, using materials differently prepared, seems to obtain a fairly consistent order.)

(3) The amount of charge generated seems practically independent of the normal pressure and independent of the relative speed of the surfaces.

(4) The amount of charge generated rises to a maximum after a certain amount of rubbing (when the surfaces rubbed remain the whole of the surfaces originally put in contact). A small fraction of the charge is given on direct contact but the great majority of the charge only results after some rubbing and then remains constant in amount, independent of further rubbing.

(5) The amount of charge produced depends on the insulation strength across the dielectric space between the rubbing substances. It is thus approximately the same for dry gases; the charges recombine if the intervening gap is made conducting; the charge is distinctly less in pure paraffin oil (which has a lower dielectric strength at these distances).

(6) The charge produced is independent of the capacity of the specimens (provided the areas rubbed remain the same); all of each charge produced remains on its respective surface until the specimens are separated.

(7) Charges can be generated by pressure, impact or rubbing; the maximum density obtained in air seems to be about 20 E.S.U./cm.^{2} (Cf. (5)).

(8) The charges do not appear to be maintained by any intrinsic potential difference; if surfaces after rubbing are left "together" the charges remain unaltered but are dissipated if the gap is rendered conducting, e.g., by ionisation.

(9) With optically flat surfaces (flat to half wave-length of sodium light) the amount of rubbing necessary for the maximum charge seems diminished.

(10) Rods apparently similar, e.g, of clean glass, can be made to yield opposite charges by rubbing one, at one fixed point, along a line on the other or by warming one; the sign may thus be changed at will.

(11) Different crystal-faces give different charges (but this effect not large enough to affect the position of the chemical compound in a series); similar faces gave no charge; the relative position of metals in the series agreed with their relative "electron affinities" as determined by ionisation potentials, thermionic effects, photo-electric effects, electrode potentials.

Reviewing the above facts, which represent the general phenomena known, it is apparent that (5) and (6) are independent of the mechanism of production of the charge and relate to the observation of the quantity of charge; again that (3) and (4) eliminate the action of "friction" in the normal sense of the term. It is also obvious that the effect is a surface one and hence is very dependent on the cleanliness and general nature of the surfaces involved. Further, it is evident that much more *quantitative* work must be done before any theory can be fully elaborated or substantiated. It seems opportune, however, to consider briefly the possibility of stating a theory if only to serve as a stimulus to further quantitative work in this field and the present communication is an attempt in this direction.*

We proceed then to postulate assumptions:—

1. At the immediate surface of a dielectric there exists a surface-field varying in magnitude and direction with the particular dielectric. (This assumption may extend to liquids.)
2. At the immediate surface of a metal there exists a similar surface-field.
3. Charging is effected by the transfer of electrons from one surface to the other.
4. Ordinarily, surfaces have adsorbed layers of gas on them masking these fields.

Examining these assumptions, 4 is more a fact of experience than an assumption; and 3 is extremely probable in view of the greater mobility of electrons because of their smaller mass. 2 seems fairly probable on the lattice theory of the structure of metals, viz., a positive atom-lattice with an interpenetrating electron-lattice. If we consider the boundary surface of such an arrangement, it seems probable that the surface electron-layer will not remain at the mean lattice-distance but will be drawn towards the inside (with consequent distortion of the surface). The exact surface configuration will depend on the relative positions of the positive ion and the electron-

*I feel that some apology is necessary for the form of this present communication but, after delaying publication for some time, I have decided that it would probably be best to publish in the general form of this paper rather than to wait until a more finished publication with references can be evolved. This will, I hope, be possible later on when more time can be obtained from routine work. The majority of the necessary references will be found in a paper by W. A. Macky, *Proc. Roy. Soc.*, A, 119, page 107, 1928.

lattices but it seems fairly probable that there will be some external field.

Assumption 1 also seems fairly probable for "solid" dielectrics. Apparent solids fall into two classes—crystals (the only real solids) and quasi-solids, such as glass which in reality are liquids of great viscosity. In crystals we have the lattice structure which at the surface will undoubtedly give surface-fields within a distance of a few molecular diameters. In the viscous liquids, the assumption is more doubtful but it can be pointed out that the Debye theory of dielectrics,* which has met with great success in the case of gases and dilute solutions, assumes permanent dipoles in the dielectric (these being oriented by an applied external field) thus giving polarisation in the dielectric. As Debye points out, some such dipoles are really to be expected as the *normal* state of matter since their absence would imply absolute symmetry in the particles and in the fields on the particles. Adsorption of all gases at the surface of glass seems to point to some surface-field as postulated.

In general, there is some considerable evidence for surface-fields of the type postulated. The work necessary to remove electrons from a metal surface necessitates such a field; contact potentials and the Peltier effect indicate variations of this field from metal to metal. The surface-energy of a crystal-face (varying with the face) must be related to the surface-fields. The alteration in the contact of mercury and glass (from convex to concave meniscus in mercury) when all adsorbed gases are removed, shows the importance of adsorption in this case and as mentioned above, the adsorption phenomena generally would support such a postulate. It is found that surface-films, one molecule thick, on liquids have definite orientations of the molecules. And, finally, on Laplace's theory of surface-tension there exists a force normal to the surface; if this, as seems probable, is electrostatic, then it will orient any natural dipoles in a solid-liquid, so that they are end-on at the surface (such a picture being the "mean" picture, exclusive of thermal agitation).

On the basis of these assumptions, we can picture the phenomena occurring when a flat solid dielectric is brought against a flat metal surface. There are the films of adsorbed gas separating the two; pressure will displace some of these molecules but only those at the "contact spots." There are thus few places of contact, but if the surfaces are rubbed together, the area of contact is greatly increased, the adsorbed "gas" film being displaced sideways. When the surfaces are within molecular distance (of the order of 10^{-7} cm.) the surface-fields become operative (beyond this the field falls off, becoming zero at greater distances since the bodies are as a whole neutral). The exact phenomena of operation of the fields will vary with the particular cases; two fields in the same direction will co-operate; but if opposed, the stronger will determine the direction of electron transfer. If the electron goes to the metal, this acquires a negative surface charge and leaves the dielectric positive (on the surface); the electrons will spread over the metal-surface; the surface of the dielectric will be strained (e.g., if a crystal, the lattice

*Marx, *Handbuch der Radiologie*, Band 6.

must be disturbed). The converse occurs if the electron transfers in the opposite sense. In either case the effect is a surface one—the quantity entering into consideration is the surface density and there will be a maximum density determined by (1) the dielectric strength when this is a limiting factor (experiments done by Mr. Macky in the Physics Laboratory here have indicated the importance of this limitation in almost all, if not all, quantitative work hitherto done on the subject), (2) the surface-density of charge necessary to neutralise the surface-field; at least on those parts operative (in the lack of absolute flatness). We might anticipate in this case an increasing density of charge with flatness of the surface, until with absolutely flat surfaces and no dielectric film in between, we should approach a surface-density of the order of that existing, by postulation, owing to natural polarization of the surface.

Obviously since the effect is a surface one, the rest of the specimens do not matter, i.e., the density obtainable is independent of the capacity of the metallic specimen. Obviously also the pressure necessary is only that for contact at the contact spots (where the actual pressure, i.e., thrust per unit area, is probably high); the relative unimportance of pressure is thus easily understood. Again the electron transfer when it does occur probably occurs very quickly and we can see the reason for the absence of any velocity effect in the rubbing.

The so-called frictional series will represent the relative actions of the surface-fields, e.g., if we state a unit F and designate a field as positive when in the direction of the outward normal, then a substance + F will become negative with respect to one with — F; 3F will be negative to 2F, and so on, if we assume equal binding of the electrons in each case. Actually, the resultant effect will be due to the difference of the algebraic sums of the external force and the binding force in each surface, e.g., if an electron is held with f′ and is acted on by F, then (F — f′ is the ejecting force. Thus the electron transfer is determined by (F — f′) — (F′ — f), i.e., (F — F′) — (f′ — f). It should be of interest to work with crystal structures and build up a predicted series.

Let us consider the external surface-fields and their action. In the case of the metal and of a true solid (a crystal), we have the fields due to lattice-structures. These can be evaluated fairly simply, once the surface-deformation is assumed, i.e., the resultant movement due to the surface-discontinuity. Without taking this into account, it is easy to calculate that the surface-field is due mainly to the outermost layer. For example, let us suppose a structure on the cubical system with every particle carrying the same charge e at an equal distance d from its neighbours, and such that planes parallel to the surface are at the same distance d, and alternatively positive and negative. If we suppose the surface-plane positive and consider a point P distant d from this plane, then the total force at P comes out as about $3.5\ {}^{e}/_{d^2}$, whereas that due to the top plane only is $4\ {}^{e}/_{d^2}$. If e is the electronic charge and $d = 5 \times 10^{-8}$, $F = \dfrac{5 \times 10^{-10} \times 4}{25 \times 10^{-16}} = c.10^{6}$ E.S.U., an enormous field $= 300 \times 10^{6}$ volts/cm.

Obviously this field falls off rapidly with the distance, thus the top plane gives a force $+ 4\ {}^e/_{d^2}$, the next one $- .86\ {}^e/_{d^2}$, the next $+ .3\ {}^e/_{d^2}$, etc., the total being about $+ 3.5\ {}^e/_{d^2}$.

If we take the point P at 2d from the plane, then we have $+ .86\ {}^e/_{d^2} - .3\ {}^e/_{d^2}$, etc.

$$\text{and } F = .5\ {}^e/_{d^2} = 10^5 \text{ E.S.U.}$$

The force is thus reduced by a factor 7 on doubling the distance. (These forces will be reduced by the distortion of the lattice at the free surface but will remain probably of this magnitude.)

A similar result follows if we consider a polarised surface, as may exist on glass, with dipoles of moment M. For a similar structure to that above, i.e., planes of dipoles parallel to the surface with distance d between the planes and a square arrangement of dipoles in any one plane, d being the side of the square, then assuming a negligible magnitude for the separation in each dipole, the field at the point P, distant d from the surface, is of the order ${}^M/_{d^3}$, actually about $10\ {}^M/_{d^3}$. In this case the decrease with distance will be still more rapid.

Now on Debye's theory, M for liquids investigated, e.g., water, alcohol, etc., is of the order 10^{-18}. If glass has a similar moment, then

$$F = \frac{10 \times 10^{-18}}{10^{-21}} \text{ (putting } d = 10^{-7} \text{ for mol.)} = 10^4 \text{ E.S.U.}$$

(This will be greater if M is larger.)

Now the action of these fields is to cause electron transfer. Recently electrons have been drawn from cold metals in the highest vacuum by the use of very large fields of the order 10^6 volts/cm. $= 3 \times 10^3$ E.S.U./cm.; the current was found to be a function of the field and independent of ordinary variation of temperature. On our conception, the field due to a suitable dielectric would act similarly and we see that ample strength of field seems to be available.

Again, when the electron transfer is from the dielectric, this corresponds to the break-down of the dielectric molecules. Assuming a similar order of phenomenon in these surfaces to that observed in a mass of the dielectric (and it seems probable that the break-down in a mass starts near the electrodes, where there is the greatest potential drop, as Joffé has found*), this transfer field should be of the same order as the break-down field that determines the dielectric strength of the material. These for good dielectrics are of the order of 10^5 to 10^6 volts/cm., i.e., 300 to 3,000 E.S.U., again a field easily realised on the above reasoning.

The effect of rise of temperature would probably be to weaken the surface-fields, both by the agitation and by the decrease in density of the packing. The experimental data are, however, very meagre as yet but some results of Shaw's show temperature effects between apparently similar rods.

In general, I think it may be said, that the theory outlined above gives a working hypothesis and seems to be at least as well-founded as any of the vaguer contact or friction ideas.

Physics Department,
Auckland University College, N.Z.

---

*Joffé, *Annalen der Physik*, 72, 461, 1923.

Food Values of New Zealand Fish.

Part 10.—Seasonal Variations in Stewart Island Oysters.

By John Malcolm, M.D.

[*Read before the Otago Institute 12th June, 1928; received by Editor, 12th October, 1928; issued separately, 25th March, 1929.*]

In previous communications (1) it has been shown that the percentage of glycogen in these oysters falls at the time of spawning, and that the vitamin-A content is high but variable—thus the samples examined in June, 1926, were less rich in that respect than the October sample of the same year.

In the present research an attempt was made to follow the variations in chemical composition and in vitamin-A throughout the oyster season of 1927—March to October inclusive—and to find out whether there was any relationship between the data obtained such as has been found to exist between the fat percentage and the vitamin-A content of ordinary fishes. In contrast to the fishes, oysters and other molluscs store glycogen instead of fat, and what is usually termed a " fat " oyster is one rich in glycogen (Mitchell, (2)).

The project enlisted the interest and support of the Fisheries Department, and the writer has to thank Mr. A. E. Hefford, Chief Inspector of Fisheries, for facilitating the collection of samples, and for other help. The samples were taken monthly by Messrs. Dixon Bros. (Bluff) from a known area. A half-sack of the oysters was forwarded as expeditiously as possible to Dunedin, and was received usually within twenty-four hours of being dredged. For the first few months they were examined, sorted out, and measured by Mr. Maxwell Young, Marine Biologist to the Fisheries Department. Later samples were similarly treated by Mr. H. C. Manson, Chief Laboratory Assistant to the Physiology Department, acting under Mr. Maxwell Young's directions. The contents of the alimentary canal from June to October were examined by Dr. Harold J. Finlay; in practically all cases the canal was empty. Observations on seasonal variation in the composition of oysters in England and in America have been published in various reports and journals (3). No similar work on seasonal variation of the vitamins in oysters has come under my notice, but the subject is referred to in a comprehensive paper on the vitamins (A, B, D) in American oysters by Jones, Murphy, and Nelson (4) which appeared in February of this year.

Chemical Composition.

Methods: From each monthly half-sackful, 250 oysters of approximately uniform size (2½ inches across), and average condition, were selected after being opened, were strained lightly in cheese cloth, weighed, minced, and the material so obtained was well mixed and samples were taken for water percentage and ash, glycogen, nitro-

gen, and fat. For the vitamin work six samples of 100 grm. each were put into cardboard containers and kept in cold storage till required.

The water percentage was obtained by drying in a hot air oven at about 100°C till approximately constant weight was attained. The same material was then incinerated to obtain the ash. At the end of the first stage of combustion a hot-water extract was made, filtered, evaporated, re-incinerated and weighed to give "soluble ash" separately from "total ash." Nitrogen was estimated by the Kjeldahl-Gunning method and the writer has to thank Mr. B. S. Irwin, B.Med. Sc., for carrying out these determinations. Glycogen was estimated in two samples of 25 grm. each by Pflueger's method, and fat by drying similar quantities, mixed with clean sand, grinding in a mortar and extracting with ether by the usual Soxhlet method—care being taken to use thoroughly dried ether to redissolve the extract before finally weighing.

The results of these estimations are given in Tables 1 and 2.

TABLE 1.—COMPOSITION OF OYSTERS.

	March	April	May	June	July	Aug.	Sept.	Oct.
Average weight	9.0g.	8.0g.	8.6g.	9.65g.	10.0g.	10.01g	12.1g.	11.45g
Water per cent....	74.00	74.40	75.73	77.08	76.50	76.13	76.04	76.11
Solids ,, ...	26.00	25.60	24.27	22.92	23.50	23.87	23.96	23.89
Nitrogen ,, ...	1.87	2.22	2.04	2.06	2.02	2.04	1.91	2.06
"Protein" % (N. × 6.25)...	11.68	13.87	12.78	12.91	12.62	12.75	11.93	12.87
Glycogen per cent.	6.71	6.39	5.07	4.69	4.92	4.69	5.22	4.36
"Fat" % (Ether Ext.) ...	2.66	2.40	2.15	2.21	2.28	2.10	2.16	1.91
Total Ash per cent.	1.48	(1.65)	1.94	2.03	2.50	2.03	2.03	2.03
Soluble Ash ,,	0.60	...	0.85	1.06	1.67	1.14	1.20	1.14
Insoluble Ash ,,	0.88	...	1.09	0.97	0.83	0.89	0.83	0.89
Unaccounted for ,,	3.47	(1.30)	2,33	1.08	1.18	2.30	2.62	2.72
Solids per oyster ,,	2.34g.	2.05g.	2.08g.	2.21g.	2.35g.	2.40g.	2.88g.	2.73g

TABLE 2.—PERCENTAGE DISTRIBUTION OF THE ORGANIC SOLIDS.

	March	April	May	June	July	Aug.	Sept.	Oct.
"Protein"	47.63	57.87	57.23	61.80	60.09	58.38	54.40	58.87
Glycogen	27.36	26.67	22.69	22.45	23.41	21.47	23.80	19.94
"Fat"	10.85	10.01	9.62	10.58	10.85	9.61	9.85	8.74
Residue	14.15	4.42	10.43	5.17	5.62	10.53	11.95	12.44

It will be noticed that there is at first a decrease in the average weight and in the solids per oyster. From May onwards these figures increase up to September. This may mean that these oysters continue to feed and grow during the winter months. On the other hand, the result may be due to the trawlers working along the oyster bed as will be mentioned later. That the September oysters were heavier than the October ones leads one to suspect that they were dredged from different ground.

The glycogen shows a more or less progressive fall but not to the same marked extent at the end of the season as was found in

previous work. Possibly the loss of spawn in the previous cases might account for the difference, for the 1927 oysters were late in spawning. The " fat " and " protein " (N x 6.25) show no significant variations—the fat in the September oysters (2.16% gross or 9.85% of the organic solids) is an average figure whereas the vitamin-A content of these oysters was higher than that of any of the others. From the point of view of chemical composition, the food-value of these oysters is much the same throughout the season, and the data supplied here do not indicate the advisability of any change in the limits of the season as at present defined.

VITAMIN-A.

Methods: Litters of young rats reared in the laboratory were put on the basal diet when about three weeks old, and were weaned at the 28th day. They were then continued on the diet which contained purified casein, starch, " crisco," and salts as described in previous papers of this series. Vitamin-B was supplied in the form of " Marmite " and vitamin-D as oxidized cod-liver oil (2%). When the weights began to fall and eye symptoms began to appear, the oyster material was given. The form in which this was used requires special mention. When minced as already described the " mush " contained small lumps of adductor muscle, gills, etc., and it was obvious that some method of more uniform comminution was necessary. In the work done on oyster in 1926 (Paper 8) and on toheroa in 1927 (Paper 9 of this series (5)) the minced shellfish was incorporated with the constituents of the basal diet so as to form a stiff paste or leaven which, when partially dried, could be ground to a fine uniform meal. When so treated there was still clear evidence of the presence of vitamin-A, and in the earlier experiments reported here the same method was adopted. The oyster leaven was brought to such a degree of dryness that it corresponded weight for weight with the fresh oyster used, so that 1 grm. meal corresponded to 1 grm. fresh oyster. But while this method gave uniform sampling it allowed some destruction of vitamin to occur, probably to an uncertain and variable extent. The best results were obtained in the last series of experiments where the leaven prepared as described above was thoroughly pounded in a mortar, and weighed out in quantities sufficient for ten days. These rations were then packed closely in large clean test-tubes and sterilized in the boiling-water bath. Although opened daily to secure the daily feed, they kept clear of moulds for the whole ten-day period. In every case the oyster material was given for ten successive days, and the cage was not cleaned out for at least ten days thereafter, so that any vitamin-A in the faeces could be used over again by the rats. During this after-period they received the usual basal diet till death occurred.

In the earlier experiments as many as three or four rats were included in a group and fed together in the same cage. While this has the advantage of giving the average effect on several rats and of saving time and labour, there is always the possibility that the vitamin ration may not be equally divided. In the later experiments with the oyster " leaven" each rat was taken out of its cage and fed separately.

For ease of comparison the data are presented in tabular form rather than as charts. (Tables 3, 4, 5). In these tables some of the columns require a word of explanation. The designation of each rat is made according to the following method: The first letter indicates the year in which the litter was used, B = 1927 in this case; the second letter indicates a certain litter born and used that year; the Roman numerals I, II, etc. indicate the groups into which that litter was subdivided. When necessary the individual rat in a group received

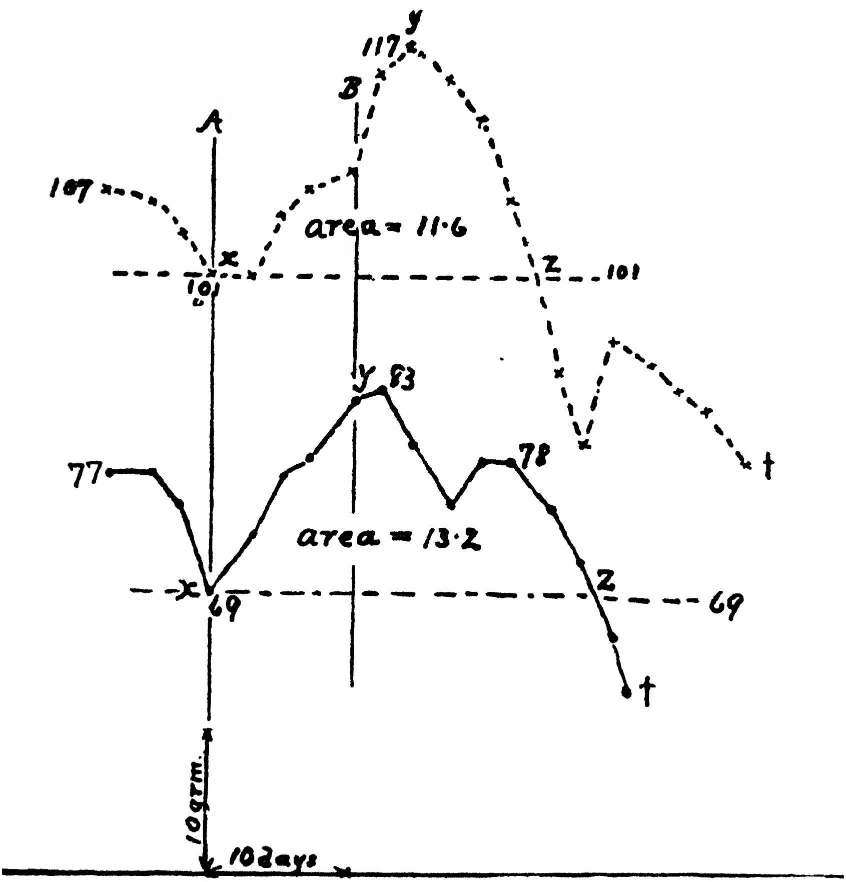


FIG. 1.—To illustrate the method of determining the relative values of effects on growth; XYZ = the "area of growth."

a number, 1, 2, etc. The second column gives the rise in weight, i.e. the difference between the weight when the special dieting began and the maximum attained during the feeding or soon after it ceased. For greater accuracy the actual weights are given in brackets. The "area of growth" in the third column was obtained by measurement of the growth-curves as follows: As stated already, after the ten

days of oyster feeding the rats were kept on basal diet till they died. Before death the weights fell usually to a lower point than that at which the feeding began. A horizontal line was drawn across the curve at this level and the included area was measured carefully in sq. cm. by a planimeter such as surveyors use for evaluation of areas on maps.* Figure 1 gives an example of this procedure. Rats Bu IV were given a meal containing oyster-spawn for ten days beginning at the point x; the maximum weight was at y, and at z the growth curve is back at the same level as x. The " area of growth " is the roughly triangular area xyz and in these cases measured 11.6 and 13.2 sq. cm. on the original chart. The advantage of this figure is that it indicates to some extent the amount of storage of vitamin-A that the rat was able to accomplish.

It is not claimed that this method can give a true mathematical measure of the amount of vitamin present in foodstuffs, but it gives a figure that can be used for comparative purposes.

The next column " Prolongation of life " gives in days the duration of life after the oyster feeding began. In the control groups (total = 30 rats) this figure averaged 20 days, and it will be noticed that the oyster feeding caused a distinct prolongation of life beyond this period whether growth had occurred or not. This figure may be regarded as an indication of a " maintenance " factor just as the " growth area" shows "growth + maintenance" factors.

The columns that refer to eye-symptoms need no further explanation, but note may be made of the fact that almost every case showed eye-trouble. That has been our experience in this laboratory during the past three years.

Comments on the Tables: Table 3 gives the results of *individual* feeding on *undried* oyster; this series was carried out late in the year, when all the samples had been received, and this made possible a certain amount of *overlapping*, i.e., the groups of one litter were given oyster material collected in different months. For these reasons the results are probably more reliable for comparative purposes than the others, and this method would have been adopted to a greater extent if the samples had all been available simultaneously, and if the best level of doseage had been known, for a great many experiments were done on the March, April, and May oysters at various levels ranging from 0.5 grm. to 3.0 grms. in order to determine the best level, viz., a dose that lay between the minimal and the just maximal. In the litter Bs three pairs (buck and doe) were fed March, May, and July oyster respectively. The area of growth and the prolongation of life indicate progressive falling off in vitamin-A content as the season advanced.

In litter Bt two pairs similarly received June and August oysters. and again there is evidence of less vitamin-A in August as compared to the earlier month, but it will be noticed Bt I showed a better result with June oyster than Bs III did on May oyster. This is probably due to a difference in the quality of the litter and not to a greater content of vitamin-A in the June as compared to the May oyster.

---

*I am indebted to my colleague Professor James Park, Director of the Otago School of Mines, for kindly giving me the loan of a planimeter, and for instruction in its use.

TABLE 3.

Rat.	Rise in weight.	"Area" of Growth.	Prolongation of life.	Initial State of Eyes.	Effect on Eyes.	REMARKS.
	grms.	*sq. cm.*	*days.*			
Bs I buck	33 (95-128)	69.6	56	slight	cured	*March* oyster as leaven. 2 grms. each.
Bs I doe	9 (90-99)	11.7	47	slight	cured	
Bs III buck	23 (100-123)	34.2	50	marked	cured	*May* oyster as leaven. 2 grms. each.
Bs III doe	10 (85-95)	14.0	44	marked	almost cured	
Bu II buck	20 (85-105)	29.2	38	marked	improved	
Bu II doe	16 (79-95)	26.5	57	marked	improved	
Bt I buck	28 (95-123)	66.7	57	marked	cured	*June* oyster as leaven. 2 grms. each.
Bt I doe	25 (72-97)	34.2	35	slight	cured	
Bs II buck	no growth	—	33	marked	no cure	*July* oyster as leaven. 2 grms. each.
Bs II doe	no growth	—	26	slight	passed off	
Bt II buck	26 (90-116)	33.5	38	marked	much improved	*August* oyster as leaven. 2 grms. each.
Bt II doe	12 (73-85)	10.9	43	slight	cured	
Bv I buck	27 (92-119)	58.7	53	marked	cured	*September* oyster as leaven. 1 grm. each.
Bv I dóe	19 (83-102)	37.0	56	slight	cured	
Bw IV buck$_1$	31 (125-156)	51.6	47	marked	cured	*October* oyster as leaven. 1 grm. each.
Bw IV buck$_2$	24 (116-140)	36.0	37	marked	cured	
Bu III buck	49 (77-121)	136.5	65	marked	cured	Tinned oyster as leaven. 2 grms. each.
Bu III doe	31 (74-105)	93.0	74	marked	cured	

TABLE 4.

Rat.	Rise in weight	"Area" of Growth	Prolongation of life.	Initial State of Eyes	Effect on Eyes.	REMARKS
	grms.	*sq. cm.*	*days.*			
Ba I buck$_1$	23 (87-110)	23.5	39	marked	almost cured	*March* oyster meal: 4 grms. to two rats.
Ba I buck$_2$	22 (103-125)	33.8	50	slight	cured	
Bb IV doe$_1$	16 (76-92)	16.1	36	slight	cured	*April* oyster meal: 6 grms. to three rats.
Bb IV doe$_2$	13 (81-94)	16.3	36	slight	cured	
Bb IV doe$_3$	15 (72-87)	16.0	40	slight	cured	
Be II buck$_1$	33 (80-113)	67.2	59	slight	cured	*May* oyster meal: 6 grms. to three rats.
Be II doe$_2$	22 (71-93)	40.3	40	slight	cured	
Be II doe$_3$	18 (69-87)	23.1	33	slight	cured	
Bj I buck$_1$	11 (75-86)	9.8	?	moderate	improved	*June* oyster meal: 4 grms. to two rats.
Bj I buck$_2$	14 (72-86)	17.4	?	moderate	improved	
Bu II buck$_1$	19 (85-104)	23.5	40	moderate	cured	*July* oyster meal: 4 grms. to two rats.
Bu II buck$_2$	19 (75-94)	24.0	41	moderate	cured	
Bu I buck$_1$	5 (87-92)	—	26	marked	slightly improved	*August* oyster meal: 4 grms. to two rats.
Bu I buck$_2$	4 (71-75)	—	26	marked	slightly improved	
Bq IV buck$_1$	55 (89-144)	134.8	65	moderate	nearly cured	*September* oyster meal: 6 grms. to three rats.
Bq IV buck$_2$	48 (77-125)	131.4	66	moderate	cured	
Bq IV buck$_3$	41 (79-120)	104.2	58	slight	cured	
Bt III buck	19 (90-109)	28.9	42	moderate	nearly cured	*October* oyster meal: 4 grms. to two rats.
Bt III doe	17 (81-98)	31.8	56	moderate	nearly cured	
Bt IV buck	13 (97-110)	19.5	44	moderate	cured	October oyster meal after spawn removed: 4 grms. to two rats.
Bt IV doe	14 (67-81)	22.1	44	moderate	improved	

TABLE 5.

Rat.	Rise in weight.	"Area" of Growth.	Prolongation of life	Initial State of Eyes.	Effect on Eyes.	REMARKS.
	grms.	*sq. cm*	*days.*			
Ba I $buck_1$	24 (92-116)	23.6	?	moderate	almost cured	*March* oyster meal: 2 grms. to two rats, later increased to 4 grms. (See Table 4).
Ba I $buck_2$	13 (82-95)	8.0	?	moderate	cured	
Ba IV $buck_1$	15 (102-117)	16.4	46	slight	almost cured	*March* oyster meal: 2 grms. to two rats, reduced to 1 grm. after 4 days.
Ba IV $buck_2$	17 (93-110)	27.0	59	slight	almost cured	
Ba II $buck_3$	no growth	—	32	slight	improved	*April* oyster meal: 2 grms. to two rats, reduced to 1 grm. after 4 days.
Ba II $buck_4$	no growth	—	37	slight	improved	
Ba I $buck_1$	20 (81-101)	35.7	47	moderate	cured	*May* oyster meal: 3 grms. to three rats.
Be I $buck_2$	19 (80-99)	19.0	40	moderate	cured	
Be I $buck_3$	31 (82-113)	56.5	47	moderate	cured	
Bg II doe_1	10 (66-76)	11.4	34	slight	cured	*May* oyster meal: 4 grms. to four rats.
Bg II doe_2	11 (67-78)	21.1	54	slight	cured	
Bg II doe_3	11 (64-75)	3.2	51	slight	cured	
Bg II doe_4	9 (65-74)	11.5	54	slight	cured	
Bk I $buck_1$	no increase			slight	no cure	*June* oyster meal: 2 grms. to two rats.
Bk I $buck_2$	7 (81-88)	6.5	32	marked	no cure	
Bk II doe_1	14 (59-73)	10.2	?	slight	improved	*June* oyster meal: 3 grms. to three rats.
Bk II doe_2	12 (62-74)	15.1	?	moderate	improved	
Bk II doe_3	23 (66-89)	14.4	?	marked	nearly cured	
Bl I $buck_1$	18 (66-84)	20.8	48	moderate	cured	*July* oyster meal: 3 grms. to three rats.
Bl I $buck_2$	12 (61-73)	17.0	46	moderate	cured	
Bl I $buck_3$	16 (73-89)	22.2	56	moderate	cured	
Bm I $buck_2$	15 (58-73)	27.3	39	moderate	slight improvement	*August* oyster meal: 2 grms. to two rats.
Bm I $buck_4$	10 (70-89) .	18.2	34	moderate	slight improvement	
Bq II buck	40 (82-122)	56.9	50	marked	nearly cured	*September* oyster meal: 2 grms. to two rats.
Bq II doe	10 (67-77)	11.3	50	moderate	nearly cured	
Bw IV $buck_3$	14 (132-146)	16.9	42	marked	cured	*October* oyster meal: 2 grms. to two rats.
Bw IV $buck_4$	22 (121-143)	28.7	53	marked	improved	

The only other striking feature is the marked improvement in the September and October oysters as compared to the July and August ones. At the 1 grm. level these are nearly as rich as any of the others at the 2 grm. level—this is shown by the " area of growth," by the prolongation of life, and the effect on the eye-symptoms, and similar results can be seen in Tables 4 and 5 when dried material was used.

In Tables 4 and 5 the only groups that " overlap " are Bu II on July oysters and Bu I on August oysters, where again the former proved the better sample, and Bt III on unspawned October oyster and Bt IV spawned oyster where weight for weight there was surprisingly little difference. There is clearly a tendency to low results in June, July, and August with a fairly high figure for March and May and a very high figure for September.

Tinned Oysters: A sample of tinned Stewart Island oysters was also examined. In making the leaven, care was taken to make the oyster solids correspond to the average of the fresh oyster. As in the case of the tinned toheroa the vitamin content was very high; thus the two rats Bu III (Table 3) fed on this material showed a much better result than their litter-mates, Bu II, fed on the same amount of May oysters. The canning of these oysters was said to have been carried out late in the season of 1926 but the exact date could not be ascertained.

Discussion: While these experiments show that when fed at the 2 grm. level these Stewart Island oysters nearly always show a high content of vitamin-A, the writer feels that the results of comparison of the oysters from month to month leaves much to be desired. If the comparison is again undertaken he would suggest that more of the " overlapping " method should be followed and that the method of comminution adopted by Jones, Murphy, and Nelson (4) should be followed—(grinding while frozen) as probably better than either the " leaven " or the " meal." As stated at the beginning of this paper it was hoped that some relationship between the gross chemical composition and the vitamin-A content might be found, but apparently such is not the case. The September oysters, though rich in vitamin, show no special peculiarity in composition, except for the fact that they were the heaviest of all. There are two likely sources of variation in the content of vitamin-A that occur to one—firstly, the oysters' food—secondly, the presence of the spawn: in regard to the first, September is the Spring in this, the Southern, Hemisphere, and with an increase in the intensity of sunlight there is likely to be a more or less rapid increase in the plankton on which the oysters feed, but in the same connection one has to remember that the successive samples could not be dredged always from exactly the same ground. The trawlers usually work the ground from east to west and there is said to be a considerable difference in the nature of the bottom and therefore probably of the food between the two extremes of the shoal.

Secondly, as to the growth of the spawn—this occurs steadily all through the winter up to the time of spawning (end of October). At this time there is a drop in the percentage of glycogen, but the vitamin content of oysters ripe for spawning and washed free of the

spawn is still a high figure (Table 4, Bt IV, last on table). The spawn also contains vitamin-A as shown by the following observation: the washings of the later October oysters was filtered and the spawn made into a meal and partially dried. Although the temperature during drying was kept low, the material browned considerably (presence of lecithin, iron salts, etc.). Two rats of litter Bu showed increase of weight—16 grm. (101-117) and 14 grm. (69-83), growth "areas" of 11.6 and 13.2 sq. cm. (Fig. 1) and prolongation of life = 37 and 30 days. Their eye-symptoms were far advanced in one case and moderate in the other when treatment began, but in the ten day period they improved greatly and if the feeding had been continued would probably have been cured. There is therefore clear evidence that both the spawn and parent oyster after losing the spawn contain considerable amounts of vitamin-A. This agrees with the results of the experiments on spawning and non-spawning oysters reported in part 8 of this series, where, weight for weight, the latter had more vitamin-A than the former.

With the growth of the spawn in the latter part of the season it is therefore natural to expect an increase in the vitamin-A content, but that the food of the oyster is in the end the more important factor is shown by the relative superiority of the March oysters, and the sudden rise in this value in the September oyster is more likely to be due to the food than to a sudden increase in the power of the spawn to store the vitamin.

SUMMARY.

Analyses of these oysters monthly from March to late in October show a high glycogen content early in the season and a more or less gradual fall up to October. Fat, protein, and ash showed comparatively little variation. The average weight of the oyster (soft parts) in oysters of approximately the same shell size increased during the season. The vitamin-A content was lower in the winter months of June, July and August than in March to May and showed a marked increase in September. No clear relationship was found between chemical composition and vitamin-A value. Both the spawn and the spawned oyster contain considerable amounts of vitamin-A as do also tinned oysters. A new method for expressing the value of the growth curves is described.

The writer begs to acknowledge with thanks the financial aid of a grant received through the New Zealand Institute. Thanks are also due to Miss Earland for her services in attending to the rats. This paper concludes the series in the meantime.

REFERENCES.

1. MALCOLM, J., *Trans. N.Z. Inst.* 1912. 44, p. 265 and 1927, 58, p. 167.
2. MITCHELL, P. H., *Bull. of the Bureau of Fisheries* 1918, 35, p. 479.
3 RUSSELL, E. S., Report on Seasonal Variation in the Chemical Composition of Oysters, 1923, *Fishery Investigation Series* 2, vol. 6. H.M. Stationery Office (Good literature references and tables of composition).
4. JONES, D. B., MURPHY, J. C., and NELSON, E. M., *Indust. and Engin. Chemistry*. 1928, vol. 20, p. 205.
5. MALCOLM, J., *Trans. N.Z. Inst.* 1928, 59, p. 85.

A Revision of the Genus Dracophyllum.

By W. R. B. Oliver, M.Sc., F.N.Z. Inst.
Director, Dominion Museum, Wellington.

[*Read before the Wellington Philosophical Society, 27th June, 1928; received by Editor, 5th October, 1928; issued separately, 25th March, 1929.*]

Plates 78–102.

The genus Dracophyllum with its allies forms a well marked group characterized by acicular or grass-like leaves aggregated in tufts at the end of the branches, and more especially by the peculiar placentation of the ovules. The ovary is 5-celled with several ovules in each cell attached to a placenta suspended from a short stipes arising from the top of the axis The group is distributed over the whole of Australia, Tasmania, New Caledonia, Lord Howe Island, and New Zealand. Three genera are now recognized as forming this group. They may be thus distinguished.

Richea.—Corolla with the lobes not separating, the upper calyptriform portion falling off entire, leaving a persistent ring.

Sphenotoma.—Corolla with spreading lobes, tube narrow, the throat almost closed by longitudinal folds at the base of the lobes.

Dracophyllum.—Corolla with spreading lobes, and a cylindrical tube without folds.

The three genera as thus defined form natural easily recognized groups, and moreover have different distributional areas. *Richea* consists of 8 Tasmanian species, one of which extends also to Victoria. *Sphenotoma* contains 6 species and is confined to Western Australia. *Dracophyllum* includes, according to the following account, 45 species and 9 hybrids distributed over Tasmania, Eastern Australia, New Caledonia, Lowe Howe Island, and New Zealand. It may be divided into three sub-genera one of which, *Oreothamnus*, contains 25 species confined, except one species in Tasmania, to New Zealand; another, *Eudracophyllum*, consists of 18 species distributed over the whole area of the genus, while the third, *Cordophyllum*, includes but a single species confined to New Caledonia. The most primitive forms constituting a section of the subgenus *Oreothamnus* have their headquarters in New Zealand, while the most advanced group *Eudracophyllum* has the widest range. The explanation of this distribution must be sought in a former land-connection between New Zealand and Australia by way of New Caledonia. The genus would originate in the New Caledonian region, where there is at present most diversity in the advanced species. The primitive forms became superseded in this region but developed extensively in New Zealand. The presence of *D. minimum* in Tasmania is to be regarded either as a survival of the primitive section of the genus on the western side of the Tasman Sea or as an accidental straggler from New Zealand.

It will be noticed that the above explanation is based upon the theory that an evolving group advances in evolution most at its point of origin, while the primitive forms get pushed towards the periphery. The distribution of *Dracophyllum* supports the theory of a former land-connection between New Zealand and New Caledonia and thus indirectly with Australia.

The multiplication of species of the subgenus *Oreothamnus* in New Zealand points to long isolation of the area and an extension of the land-surface. This however does not conflict with the theory advanced above that the genus originated in the New Caledonia region.

Acknowledgements.—In order to determine the relationships of all the known species of *Dracophyllum* it was necessary for me to examine as many specimens as possible. In Wellington the Dominion Museum, Petrie and Kirk herbaria are available. Further afield are other important collections containing species not represented in Wellington. I therefore applied for and was courteously loaned specimens by Dr. Darnell-Smith, Director of the Sydney Botanic Gardens, Mr. C. T. White, Government Botanist, Brisbane, and Mr. J. W. Audas, Acting-Government Botanist, Melbourne. A similar courtesy was extended by Mr. Gilbert Archey, Curator of the Auckland Museum, under whose charge is the Cheeseman herbarium. Mr. H. Carse very kindly spent much time and trouble in selecting the specimens I required, besides sending me a series from his own herbarium. At a later date I personally examined the specimens of *Dracophyllum* in the Cheeseman Herbarium. To Dr. A. W. Hill, Director of the Royal Botanic Gardens, Kew, I am indebted for a portion of the type specimen of *Dracophyllum scoporium*. To all the above-mentioned gentlemen I desire to record my sincere thanks. I have also to thank Drs. L. Cockayne and H. H. Allan, and Messrs. R. M. Laing and F. G. Gibbs for the loan of specimens; Mr. L. Rodway, Government Botanist, Hobart, for sending a specimen of *D. minimum*; and Professor Arnold Wall for kindly examining and reporting on the type specimen of *D. rosmarinifolium* in the British Museum. The photographs (except Fig. 22) have been prepared by Mr. B. Osborne of the Museum staff.

Dracophyllum.

The first species of *Dracophyllum* to be described was *D. longifolium,* for which with two other species of New Zealand plants Forster (*Char. Gen.* 1776) founded the genus *Epacris*. *Epacris* in this sense has been abandoned, and the name is now used for an Australian genus containing none of the species enumerated by Forster. A second species of *Dracophyllum* (*D. rosmarinifolium*) was referred to Forster's genus *Epacris* in 1786 (*Forster Fl. Ins. Austr. Prodr.*). Labillardiere in 1800 (*Voy. Nov. Holl.*, p. 211) founded the genus *Dracophyllum* for *D. verticillatum* of New Caledonia. This is one of the advanced forms related to the larger New Zealand species. The first enumeration of the New Zealand species of the genus was Richard's account (*Voy. Astrolobe Bot.* 1832) in which 4 species are mentioned. This and later accounts of the New Zealand species are tabulated below:—

Richard, *Voy. Astrolobe Bot.* 1832	4 species.
Cunningham, *Ann. Nat. Hist.*, vol. 2, 1838	5
Decandolle, *Prodr. Syst. Nat.*, vol. 7, 1838	5
Hooker, *Flora Antarctica* 1844	12
Raoul, *Choix Pl. N.Z.* 1846	11
Hooker, *Flora Nov. Zel.* 1853	14
Hooker, *Handb. N.Z. Flora* 1864	11
Cheeseman, *Man. N.Z. Flora* 1906	18
Cheeseman, *Man. N.Z. Flora* 1925	20

In the present account 32 species are admitted as belonging to the New Zealand region.

Habitat.—The New Zealand species of *Dracophyllum* are for the most part plants of the scrub above the forest-belt. On all the mountain ranges in New Zealand there is above the forest-belt a zone of scrub which in many cases has a species of *Dracophyllum* as a dominant member. Thus *D. rosmarinifolium* is common in the South Island with *D. pronum* or *D. politum* as a prostrate scrub higher up the mountain side. In the North Island *D. recurvum* is found from the forest-line to nearly the upper limit of vegetation. In swamps the tall shrubby species *D. longifolium* and *D. filifolium* are often found. In the forest are the arborescent species such as *D. latifolium, D. Traversii, D. filifolium, D. longifolium* and others.

Habit.—The life forms of the species of *Dracophyllum* range from small dense cushion-plants a few cm. in diameter (*D. muscoides*) to forest trees 10-15m. tall. The habit is a useful character for recognizing the species but is not of any taxonomic value.

Leaf.—The characters of the leaves are used in delimiting the species and also in defining the groups of species. I value the leaf-characters for the smaller groups of species higher than those of the inflorescence because they appear to be more constant. This is shown by the fact that no considerable amount of variation in the leaf occurs in any species except *D. longifolium,* whereas the same species may have flowers arranged singly or in few-flowered racemes.

In all the species the leaf consists of a distinct lamina and sheath. The lamina may be stiff and acicular with the adaxial surface hollowed, or it may be flat and grass-like.

In the more primitive species the leaf is acicular; in the large specialized kinds it is large and flat. If the species be arranged in a series beginning with those with solitary flowers and ending with those with compound panicles, then the leaves roughly fall in a parallel series from acicular to broad flat lamina.

No similar series is shown by the leaf-sheath. In the species with acicular leaves (*D. pronum,* for instance) it is the suddenly-expanded and membraneous base of the leaf. In those species having racemes with deciduous bracts it is highly developed and auricled above (*D. longifolium, D. filifolium*). It may be least developed in the panicled species, *D. fiordense* for example showing no definite sheath and having a narrow base of attachment.

Bracts.—The bracts (floral leaves of Bentham) are of some taxonomic importance as they exhibit degrees of specialization corresponding with that of the inflorescence on which I have based the

classification given below. In the group of species possessing solitary flowers there is a gradual transition from foliage-leaves to sepals, the latter being not all of the same size. In the outer ones the lamina and sheath are abruptly marked off as in the leaves, the sepals end in a hard point which below gradually widens into the sheath (*D. rosmarinifolium*). In the higher groups, namely, those possessing racemes or panicles, there are distinct bracts each accompanied by two bracteoles. The bracts are most specialized in the panicled species. In *D. longifolium,* which has racemes, there is to each flower a leaf-like bract with a short acicular point and two small broad membranous bracteoles. The sepals in this species are of unequal size. In *D. Traversii* which belongs to the group with panicled inflorescences there is a larger bract subtending each fascicle of flowers. Within this are two small bracteoles. Each flower is also subtended by a bract and two bracteoles. The calx-segments are of equal size. Thus differentiation of the bracts proceeds apace with complexity in the inflorescence. There is a conspicuous exception to this rule of evolution. *D. involucratum* has a long compound inflorescence, but each flower is borne on a separate pedicel clothed with bracts resembling the leaves of those more primitive species of the genus which have solitary flowers. Thus evolution in the genus has proceeded along different lines affecting different organs differentially, for in *D. involucratum* one may say that while the inflorescence and leaves have advanced far, the flower-bearing branches have remained in their primitive state.

Inflorescence.—The inflorescence has been used as a basis for dividing the genus into subgenera. There is a distinct break between the raceme and panicle and another between either of these and the peculiar spike-like raceme of *D. involucratum.* With these changes correspond others, such as specialization in the bracts and differences in the relation between anthers and corolla-tubes.

In the subgenus *Oreothamnus,* the inflorescence is either a solitary flower or a raceme. One passes gradually into the other by the flowers becoming clustered and the subtending bracts becoming differentiated according to their position, the lowest being most leaf-like. When the bracts fall early as they do in *D. longifolium* a more specialized racemose inflorescence results. In the subgenus *Eudracophyllum* the fascioles are to a lesser or greater degree compound and the bracts are deciduous. The panicle may terminate the large leaf-clusters or it may be below it. In the latter case, though described as latereal, it really terminates a short lateral branch. In the species *D. involucratum,* which alone forms the subgenus *Cordophyllum,* there is a terminal spike-like raceme with the flowers in whorls, each on a separate pedicel clothed with small bracts.

Flowers.—The corolla is in most of the species narrow tubular with the anthers included. In certain species of the panicled forms, however, namely the groups containing *D. Menziesii, D. latifolium,* and *D. verticillatum,* the corolla-tube is short and wide and the anthers are exserted. In the group of *D. Fitzgeraldi* the corolla-tube is long and the anthers exserted.

The sepals in the subgenus *Oreothamnus* are bract-like and of different sizes. In the subgenus *Eudracophyllum* they are in those species with short corolla-tubes, short, rounded, and of equal size.

In the following synopsis the hybrids are attached to those species groups with the diagnoses of which their prevalent forms most agree, but it must be remembered that a series of hybrids between any two species may include forms grading into both parents.

SYNOPSIS OF THE SPECIES.

Subgenus *Oreothamnus.* Flowers solitary or in simple racemes.

A. Flowers mostly solitary, sometimes in few-flowered racemes.

(a) Group of *D. minimum.* Flowers terminal. Leaves acicular.
muscoides.—Leaves 2-3 mm., narrow.
minimum.—Leaves 4-6 mm., broad.
prostratum.—Leaves 5-6 mm., broad.
pronum.—Leaves 6-12 mm., narrow.
politum.—Leaves 10-12 mm., broad, stout.
Pearsoni.—Leaves 30 mm., stout. Flowers mostly in few-flowered racemes.

Hybrids.

× *erectum.*—Leaves 7-9 mm., narrow.
× *saxicolum.*—Leaves 13 mm., broad.

(b) Group of *D. rosmarinifolium.* Flowers axillary; leaves acicular.
rosmarinifolium.—Leaves 30 mm., broad.
peninsulare.—Leaves 100-120 mm., narrow.
palustre.—Leaves 30 mm., narrow.
subulatum.—Leaves 20 mm. Flowers mostly a few-flowered racemes.

(c) Group of *D. Kirkii.* Flowers axillary. Leaves broad, grass-like.
Kirkii.—Leaves glabrous.
pubescens.—Leaves pubescent. Flowers mostly in few-flowered racemes.

B. Flowers in racemes. Bracts persistent.

(1) Racemes lateral.

(a) Group of *D. scoparium.* Leaves short, narrow, ciliolate.
scoparium.—Leaves 30-60 mm., tomentose above.
paludosum.—Leaves 30-40 mm., margins ciliate.
arboreum.—Leaves 50-80 mm., juvenile leaves 100 mm.

(b) Group of *D. urvilleanum.* Leaves long, narrow, acicular.
Urvilleanum.—Leaves 70 mm. Corolla short. Bracts with short sheaths.
filifolium.—Leaves 130-160 mm. Corolla short. Bracts with long sheaths.
collinum.—Leaves 80-100 mm. Corolla long, 6 mm. Sepals equal to corolla tube.
Lessonianum.—Leaves 60-100 mm. Corolla long, 6 mm. Sepals longer than corolla tube.

Hybrids.

× *vulcanicum.*—Leaves short, narrow, base auricled.
× *marginatum.*—Leaves short, narrow, base not auricled in upper leaves.

(c) Group of *D. squarrosum.* Leaves broad.
squarrosum.—Leaves 50 × 3 mm., juvenile leaves 140 × 7 mm.
patens.—Leaves 40 × 6 mm. Thick.
viride.—Leaves 55 × 5 mm. Thin. Racemes lax. Juvenile leaves 160 × 8.

Hybrid.

× *densiflorum.*—Leaves 30 mm.

(2) Racemes terminal.

Group of *D. recurvum.*
recurvum.—Leaves 20 mm., recurved.

Hybrids.

× *varium.*—Leaves 50 mm., broad.
× *arcuatum.*—Leaves 30-40 mm., narrow.

C. Flowers in racemes. Bracts deciduous.

Group of *D. longifolium.* Leaves broad.
longifolium.—Leaves long, stout.
Adamsii.—Leaves short, thin.

Hybrids.

× *acicularifolium.*—Leaves 30-60 mm. Flowers solitary or in racemes.
× *insulare.*—Leaves 40-60 mm., tomentose above.

Subgenus *Eudracophyllum.* Flowers panicled.

A. Panicles below the leaves, drooping.

Group of *D. Menziesii.*
Menziesii.—Leaves 100-150 mm. Width 15 mm.
Townsoni.—Leaves 170 × 11 mm. to 260 × 14 mm.
fiordense.—Leaves 670 × 48 mm.

B. Panicles terminal.

(1) Panicles with few flowers in the lateral branches. Anthers included in corolla tube (except *Thiebautii*).

Group of *D. secundum.*
strictum.—Leaves 80 × 7 mm. Sepals short. Corolla 4 mm.
ramosum.—Leaves 125 × 11 mm. Sepals long.
secundum.—Leaves 140 × 7 mm. Sepals long. Corolla 6 mm.
Vieillardii.—Leaves 70 × 6 mm. Sepals long. Corolla 6 mm.
amabile.—Leaves 80 × 6 mm. Sepals short. Corolla 4 mm.
gracile.—Leaves subacicular 50 × 1.5 mm.
Thiebautii.—Leaves narrow, 120 × 4 mm. Anthers exserted.

(2) Panicle compound. Anthers exserted.

(a) Group of *D. Milligani.* Corolla long, sepals acute.
Sayeri.—Bracts short, tapering. Sepals short.
dracaenoides.—Bracts not seen. Sepals short.
Milligani.—Bracts long, tips recurved. Sepals long.
Fitzgeraldi.—Bracts short, broad suddenly narrowed to short point. Sepals nearly as long as corolla tubes.

(b) Group of *D. latifolium.* Corolla short, sepals obtuse.
latifolium.—Bark rough. Leaves large. Panicles erect. Flowers reddish.
Mathewsii.—Bark rough. Leaves small. Panicles decurved. Flowers purple.
Traversii.—Bark smooth, pedicels short. Branches of panicle at acute angles.
recurvatum.—Bark smooth, pedicels short. Branches of panicle at right angles.

(c) Group of *D. verticillatum.* Spike very long. Few flowers in lateral fascicles.
verticillatum.—Spike 70 cm. Leaf 45 cm.

Subgenus *Cordophyllum.* Flowers in dense fascicles each on a separate pedicel clothed with numerous bracts.
involucratum.—Spike 40 cm. Leaf 30 cm.

Oreothamnus F. v. Muell.

Oreothamnus F. v. Muell. *Fragr. Phytogr. Austr.* 1, 39, 1858.
Type *D. minimum* F. v. Muell.

Flowers solitary or in simple racemes. Sepals acute, equal to the length of the corolla-tube. In some species such as *D. Pearsoni, D. subulatum, D. pubescens,* and *D. scoparium* both solitary flowers and few-flowered racemes may be present on the same plant.

The subgenus *Oreothamnus* includes all those species of *Dracophyllum* which I regard as the most primitive members of the genus. This theory is based on the relative simplicity of the infloresecnse and bracts, and on the fact that in some species the leaves, bracts, and sepals form a graded series. The flower might be considered as specialized in its united petals and filaments, but this is a character of the family.

With the exception of one species in Tasmania (*D. minimum*) the subgenus is confined to the New Zealand region, being especially developed in the scrublands though several species are arborescent and belong to the middle foliage-tier of the forest.

Group of *D. minimum.*

Prostrate or semi-prostrate shrubs. Leaves acicular. Flowers generally terminal, solitary or sometimes in few-flowered racemes. The members of this group can usually at once be recognized by their low stature, small acicular leaves, and solitary flowers. *D. muscoides* differs from all the other species in its very small leaves; *D. minimum*

and *D. prostratum* are most alike in possessing short leaves clothing the branchlets; *D. pronum* has short leaves in tufts at the end of the branchlets; *D. politum* and *D. Pearsoni* have stout acicular leaves clothing the branchlets.

D. minimum is confined to Tasmania; of the remainder, four are found in the extreme south of New Zealand, and one is distributed through the mountains of the South Island. The distribution of this group illustrates the law of primitive species being found at the periphery of the area covered by a genus.

Dracophyllum muscoides Hook. f.

Dracophyllum muscoides Hook. f. *Handb. N.Z. Fl.* 183, 1864 (Alps of Otago). Cheeseman, *Man. N.Z. Fl.* 710, 1925. Buchanan, *Trans. N.Z. Inst.,* 14, 346, pl. 26, 1882.

Characters.—*D. muscoides* possesses the smallest leaves of all the species of *Dracophyllum.* The leaf including the sheath is about 3 mm., the lamina being narrow, but widens rather suddenly into a broad sheath. The branches are clothed with closely-imbricated leaves. Sepals reaching to the top of the corolla tube which is 2-2.5 mm. long. The plants form low dense cushions a few cm. in diameter. It is nearest allied to *D. prostratum,* but differs in its more compact habit and shorter leaves and flowers.

Distribution.—The area in which this species is found includes the dry mountains of South Canterbury and northern and eastern Otago between 1,200 and 2,000 m. altitude. Outside this region it has been discovered on The Hump in the Fiord district, altitude 1,067 m. (Specimens examined) Rock and Pillar Ra., Mt. St. Bathans, The Hump. Mt. Earnslow, Old Man Ra. Mt. Pisa, Mt. Alta. (Recorded), Hector Mtns., Mt. Ernest, Mt. Cardrona, Ben Lomond.

Dracophyllum minimum F. v. Muell. (Fig. 1.)

Dracophyllum minimum F. v. Muell., *Fragm. Phytogr. Austr.* 1, 39, 1858. (Mount La Perouse). Bentham, *Fl. Austr.* 4, 265, 1869.

Characters.—Forms small cushions 5 cm. across and 1.5 cm. high, or the erect clustered branches may be 4-5 cm. tall. Leaves 5-6 mm., lax or closely appressed to the stem. Flowers solitary, terminal, corolla-tube 4 mm. long, anthers included. This species resembles *D. prostratum* but has rather broader leaves; in habit it is more compact, and the corolla-tube is considerably longer being 4 mm. instead of 3 mm.

As indicated by the difference in habit, there may be two species in Tasmania. If so, the name *minimum* should apparently be applied to the prostrate species as it is this form which is represented in the Melbourne Herbarium.

Distribution.—Western mountains of Tasmania. (Specimens examined) Lake Dora, Mount Rufus. (Recorded) Mt. Humboldt, Mt. La Perouse (type).

Dracophyllum prostratum Kirk.

Dracophyllum prostratum Kirk. *Trans. N.Z. Inst.* 13, 384, 1881 (Mountains above Lake Harris). Cheeseman *Man. N.Z. Fl.* 710, 1925.

Characters.—A prostrate plant with creeping stems giving off long terminal branches clothed with small acicular leaves. In this last character it is allied to *D. minimum* and *D. muscoides,* but differs from *D. pronum* in which the ultimate branches are usually short with the leaves tufted at the tips. Other distinctive characters are the small flowers, corolla 3 mm., and small acicular leaves, 5-6 mm. in length including the sheaths. The branches are flexible and the bark brown.

Hybrids.—On Maungatua this species hybridzes freely with *D. rosmarinifolium* producing a series of forms (× *D. erectum*).

Distribution.—The dry mountains of South Canterbury and north and east Otago, from 800 to 1,500 m. altitude. (Specimens examined) Mountains above Lake Harris (type), Mount St. Bathans, Hooker Valley, Maungatua Hill, Longwood Range, Takitimu Mountains. (Recorded) Clinton Valley, Blue Mountains, Ben Lomond.

Dracophyllum pronum W. R. Oliv., new name. (Fig. 2.)

D. rosmarinifolium Hook. f. *Fl. Ant.* 1, 48, 1844. *Fl. Nov. Zel.* 1, 171, 1853; *Handb. N.Z. Fl.* 183, 1864 (in part, not R. Br.). *D. rosmarinifolium* Cheeseman *Man. N.Z. Fl.* 427, 1906; 2nd Ed. 709, 1925 (not R. Br.). *D. muscoides* Armstrong, *Trans. N.Z. Inst.*, 13, 342, 1881 (not Hook. f.). *D. rosmarinifolium* Betts, *Trans. N.Z. Inst.* 51, 155, 1919 (not R. Br.).

This species was first included by Hooker under Forster's name *rosmarinifolium,* and, with or without *D. politum,* has since always been referred to by the same name. Actually however, as shown below, Forster's plant is the one generally known as *uniflorum. D. politum* is a distinct species, so that it becomes necessary to give the present species a new name. Cheeseman suspected that his *rosimarinifolium* might not be the same as Forster's, but not having seen Forster's type made no alteration.

Characters.—The distinctive characters of *D. pronum* are the prostrate habit, with stiff branches covered with grey bark, and bearing the leaves in tufts at their tips. The young shoots are covered with leaves for some distance from their tips. Leaves acicular, with a short, broad membranous sheath; sheath 3-4 mm., lamina 6-11 mm. long. Flowers solitary, terminating the lateral branches; corolla-tube 4 mm. long. Sepals as long as the corolla-tube.

D. pronum differs from *D. prostratum* in its longer leaves disposed in tufts at the tips of the branches, in its rigid habit, its grey bark and larger corolla-tube. From *D. politum* it differs in its usually longer leaves disposed in tufts, and its exposed flowers. It looks very different from the densely-foliaged *D. politum* where the flowers are almost concealed. Dried specimens of *D. pronum* may be recognized by the greenish leaves in small tufts, and grey bark, characters which distinguish it from both *D. prostratum* and *D. politum.*

Forms.—*Dracophyllum pronum* shows certain differences in life form and size according to habitat. In exposed alpine stations it is a low prostrate shrub closely hugging the rocky surface, and with scant foliage in tufts at the tips of the branches. In such situations the leaves are often reduced to 5-6 mm. in length. In shrub formations at lower altitudes the plants are more laxly branched and taller with the leaves 10-11 mm. in length. In bogs the species becomes a scrambling shrub with long wiry stems with few branches. These observations were made on the mountains above Arthurs Pass.

Hybrids.—In the Arthurs Pass district *D. pronum* grows in association with *D. Kirkii,* and there is occasionally found a form which seems best explained by being a hybrid between these two species (× *D. saxicolum*).

Distribution.—Mountain districts from north Otago through Canterbury to Nelson from 800 to 1,800 m. altitude. (Specimens examined) Mount Rochfort, Mount William, Mountains above Arthurs Pass, Ben More, Mount Torlesse, Hooker Glacier, Mount Arnold, Mount Ida, Mount Dobson Range, Wairau Mountains (Nelson), Mount Captain (Amuri), Eweburn Creek, Broken River.

Dracophyllum politum (Cheesem.) Ckne. (Fig. 3.)

D. rosemarinifolium var. *politum* Cheeseman, *Man. N.Z. Fl.* 427, 1906. *D. politum* (Cheeseman) Cockayne, *Bot. Surv. Stewart Id.* 43, 1909, Cheeseman *Man. N.Z. Fl.* 709, 1925.

Characters.—A prostrate shrub with the branchlets densely clothed with stout acicular leaves with broad sheathing bases. The leaves dry reddish-brown and the ultimate branches have brown bark. The flowers are solitary and almost hidden by the leaves. In the closely-imbricating leaves this species resembles the much smaller *D. prostratum.* I consider, however, that its nearest ally is *D. Pearsoni* which it resembles in its densely-imbricating brown leaves, but in *D. Pearsoni* the leaves are much longer and the flowers are usually in few-flowered racemes.

Habitat forms.—Always a prostrate shrub, this species may be wide spreading as is usually the case in sub-alpine scrub. On the exposed top of the Remarkable Range in the south of Stewart Island it occurs as a compact almost cushion-like mass with short branches and compact foliage. The leaves of such specimens are 7 mm. including the sheath. In the ordinary state the total length of the leaf is about 10 mm.

Distribution.—Stewart Island, South Otago, from 300 to 1,100 m. altitude. (Specimens examined) Rakiahua, Remarkables, and Mount Anglem in Stewart Island. Maungatua Hill, the Hump, Mt. Barber, and Mount Aspiring, in Otago.

Dracophyllum Pearsoni Kirk.

Dracophyllum Pearsoni Kirk, *Trans. N.Z. Inst.* 17, 223, 1885, Cheeseman *Man. N.Z. Fl.* 706, 1925.

Characters.—A small erect shrub. Leaves stout, acicular, brown, densely clothing the branches, sheath 6, lamina 20 mm. Flowers in few-flowered racemes near the ends of the branches. This species

resembles *D. politum* in the imbricating brown leaves but differs in the leaves being straighter and longer, in the flowers being in small racemes, and in the erect habit of the plant.

Distribution.—Stewart Island, from 300 to 950 m. altitude. (Specimens examined) Fraser Peaks, Remarkables, Mount Anglem, Smiths Lookout.

× **Dracophyllum erectum** n. hybr. sp.
(*D. prostratum* × *D. rosmarinifolium.*)

Frutex parvus erectus; foliis acicularibus, 10-12 mm. longis, imbricatis; floribus, solitariis, terminalibus, 4 mm. longis.

Found on Maungatua in association with *D. prostratum* and *D. rosmarinifolium.* In its characters it is intermediate between these two species and it is therefore presumed to be a hybrid between them.

Characters.—A small erect shrub with the ultimate branches long and laxly clothed with small acicular leaves. Leaf-sheaths broad, membranous, edged with white. Flowers solitary terminal. The elongated branchlets clothed with acicular leaves is a character of *D. prostratum,* but the length of the leaves and their white-edged sheaths seems to be due to the influence of *D. rosmarinifolium.*

Distribution.—Maungatua Hill, 900 m. altitude. Hunter Mountains.

× **Dracophyllum saxicolum** n. hybr. sp.
(*D. pronum* × *D. Kirkii.*)

Frutex prostratus; foliis linearibus, planis, 13 mm. longis fasciculis; floribus solitariis, 6 mm. longis.

This form occurs sparingly on the mountains above Arthurs Pass in company with *D. pronum* and *D. Kirkii.* The leaves are intermediate between those of these species so that it is presumed that it is a hybrid between them.

Characters.—A prostrate shrub, the branches flattened against the ground as in *D. Kirkii.* Leaves linear, but broader and flatter than in D. pronum, and slightly glaucus and ribbed, thus resembling *D. Kirkii.* Corolla-tube 6 mm. *D. saxicolum* resembles *D. pronum* in the small leaves disposed in clusters at the tips of the branches, but it departs from this species and approaches *D. Kirkii* in the slightly broad glaucous leaves and large flowers.

Distribution.—Mountains above Arthurs Pass.

Group of *D. rosmarinifolium.*

Erect shrubs with acicular leaves, 20-120 mm. long, and axillary flowers, solitary or in few-flowered racemes. This group is distinguished from the group of *D. minimum* by its upright habit, and axillary flowers, that is, the flowers are borne on short lateral branches. *D. rosmarinifolium* and *D. peninsulare* are dense shrubs with large flowers; the other species are slender shrubs with small flowers, those of *D. palustre* being solitary, while those of *D. subulatum* are usually in few-flowered racemes. *D. palustre* is found sparingly throughout the South Island; *D. rosmarinifolium* is more frequent there and extends to the Tararua Range as well; *D. subulatum* is confined to the central portion of the North Island, *D. peninsulare* to Banks Peninsula.

Dracophyllum rosmarinifolium (Forst.) R. Br. (Fig. 4.)

Epacris rosmarinifolia Forst. *Fl. Ins. Austr. Prodr.* 13, 1786 (Dusky Sound). *Dracophyllum rosmarinifolium* R. Br. *Prodr. Fl. Nov. Holl.* 556, 1810 (not Hook. f. *Fl. Ant.* 1, 48, 1844 nor subsequent authors). *D. uniflorum* Hook. f. *Handb. N.Z. Fl.* 182, 1864, Cheeseman *Man. N.Z. Fl.* 709, 1925. *D. acerosum* Berggren, *Minn. Fisiog. Soll. Lund.* 15, 1877.

Forster described *Epacris rosmarinifolia* from specimens collected at Dusky Sound during Cook's second voyage to New Zealand. His name was listed in several subsequent works including Brown's *Prodromus* where it was mentioned as belonging to Labillardiere's genus *Dracophyllum*. The first botanist to apply the name to specimens collected in New Zealand after Forster's visit was Sir J. D. Hooker and he associated it with the species in this account, named *D. pronum*. Hooker was followed by all subsequent authors who wrote on the plants of New Zealand. Doubt of the correctness of Hooker's action was however raised by the fact that New Zealand botanists had not collected the species (*D. pronum*) in or near the locality visited by Forster. Cheeseman in his *Flora* stated that the *D. rosmarinifolium* of his work may not correspond with Forster's type which he had not been able to see. During the time I was writing this paper, Professor Arnold Wall, of Christchurch, was visiting England, so I asked him specially to examine Forster's type with a view to settling its identity. This Professor Wall did, and very kindly wrote to me from London under date June 14th, 1928, as follows:—

"To-day I went to the British Museum (South Kensington) and saw Forster's type. There is one small twig only with no fruit or flower, locality not stated, but certainly Dusky Bay, as I also saw Forster's drawing of the plant which shows flowers and an analysis thereof and gives Dusky Bay as locality. The leaves are exactly one inch long. The only other specimen of *D. rosmarinifolium* there is one of Kirk's from Amuri, which is exactly the same plant as Forster's (in the drawing the plant is called *Epacris rosmarinifolia*). It was plain to me at once that Forster's plant (and Kirk's) is simply what we now call *D. uniflorum*. I got out the specimens of that species and Dr. Rendle agreed with me that they perfectly match the *D. rosmarinifolium* of Forster."

This finally settles the identity of Forster's *Epacris rosmarinifolia*, and New Zealand botanists are in debt to Professor Wall for clearing up the point.

Characters.—As pointed out by Hooker the characters by which this species may be recognized are the short pungent leaves and the large solitary flowers. The leaves are, however, longer than Hooker states, averaging 30 mm., though many examples have them only 20 mm. The corolla-tube is 6 mm. in length. Generally this species forms an erect, dense shrub, which when dominating the alpine scrub may be recognized at a distance as dark patches often forming a belt above the forest-line. *D. rosmarinifolium* is allied to *D. palustre* by its small leaves and solitary flowers, but its dense habit easily marks it off while the leaves are broader and longer and the flowers longer.

Forms.—At least two forms, apparently not depending on habitat, may be recognized. In one the leaves are narrow, less than 1 mm. in width, and may reach a length of 35 or 40 mm. This seems to be the prevalent form of the Tararua Ranges, Nelson, and Canterbury. The other form has short leaves, up to 25 mm. in length, and 1.5 mm. broad. This form is found in Otago (Mount Barber). Forster's type agrees with this broad-leaved form. A form perhaps depending on habitat has been sent me by Messrs. J. Scott Thomson and G. Simpson. It forms a shrub with pendant branches 1½ m. long and narrow leaves 30-50 mm. long. It occurs on rock faces near Deep Stream in Central Otago.

Hybrids.—*D. rosmarinifolium* appears to hybridize with *D. longifolium* wherever the two species come together (× *D. acicularifolium*). It also crosses with *D. prostratum* on Maungatua Hill (× *D. erectum*).

Distribution.—In scrub above the forest-line from the Tararua Ranges to the South of Otago. Common everywhere, often the dominant plant in the formation. (Specimens examined) Mount Holdsworth, Mineral Belt, Mount Arthur, Buckland Peaks, Jacks Pass, St. James (Amuri), Ben More, Mount Torlesse, Mountains above Arthurs Pass, Maungatua Hill, Hector Mountains, Lake Wakatipu, End Peak, Takitimu Mountains, Wairau Mountains. (Recorded) Rangitata Range, Mount Fyffe.

Dracophyllum peninsulare n. sp.

Frutex erectus; foliis acicularibus, 100-180 mm. longis, 1 mm. latis, basis 20 mm. longis, auriculatis, ciliatis; floribus solitariis, sepalis acuminatis, ciliatis, corollis 7 mm. longis.

Characters.—*D. peninsulare* is a very distinct species, easily recognized by its large solitary flowers and long acicular leaves. It is an erect shrub 1 m. tall or more with purplish-brown bark. The leaves are narrow linear, with long oblong sheaths usually unequally truncated and auricled at the top, the shoulders being ciliated. Length of lamina 100-190 mm., breadth 1 mm., sheath 20 × 5 mm. Flowers solitary, several below the terminal clusters of leaves. Sepals long, acute, with margins and backs ciliated. Corolla-tube 7 mm. long.

The large solitary flowers place *D. peninsulare* in the group of *D. rosmarinifolium* but it differs from the other species of the group in the long acicular leaves. The leaves quite resemble those of the group of *D. Urvilleanum*.

Distribution.—Banks Peninsula. Abundant 480 m. and upwards. (Laing).

Dracophyllum palustre Ckne., new name.

Dracophyllum uniflorum var. *virgatum* Cheeseman, *Man. N.Z. Fl.* 427, 1906, 2nd Ed. 709, 1925. *D. virgatum* (Cheeseman) Cockayne, *Trans. N.Z. Inst.*, 44, 53, 1912.

Characters.—This species is distinguished by its strict habit, the long slender stems bearing flowers singly and laterally. The leaves are narrow, short acicular, 20-25 mm. long. Flowers with short

corolla-tube, 4-5 mm. long, lobes acute. *D. palustre* is allied to *D. rosmarinifolium* by its solitary flowers and narrow short leaves, but it differs in its slender strict habit, small leaves and small flowers arranged on short peduncles some distance below the tips of the branches. A character common to the two species is the pale margin to the bracts. In its habit and leaves *D. palustre* resembles *D. subulatum,* which species however has much shorter corolla-tubes and the flowers generally in few-flowered racemes. The Mount Frederic specimens of *D. palustre* have some of the flowers in racemes.

Distribution.—Nelson, North Westland and Otago, in swamps, sea level to 500 m. altitude. (Specimens examined) Waimangaroa River, Cedar Creek, Mount Hope, Mount Frederic, Denniston, Lake Brunner, Kumara, Mount Ida, Mount Earnslaw.

Dracophyllum subulatum Hook. f.

Dracophyllum subulatum Hook. f. *Fl. Ant.* 1, 50, 1844. Cheeseman *Man. N.Z. Fl.* 707, 1925; *Ill. N.Z. Fl.* pl. 132, 1914. *D. angustifolium* Colenso, *Trans. N.Z. Inst.* 28, 603, 1896.

Characters.—*D. subulatum* is characterized by the slender erect branches, small reddish leaves, 20-30 mm. long, and small flowers, 2-3 mm. long, in few-flowered racemes or solitary. A further noticeable character is the light margin to the bracts. In all these characters it resembles *D. palustre,* which species, however, differs in the flowers being almost always solitary, the corolla-tube being a little longer and the light margin to the bracts being more pronounced.

Habitat forms.—Growing in warm ground in *Leptospermum ericoides* association at Waiotapu this species tends to lose its slender form, the branches spreading out into a more bushy form. The branches are pale grey, perhaps caused partly by a deposit of sulphur, and the leaves instead of being strict are spreading and flexuose.

Hybrids.—*D. subulatum* hybridizes with *D. filifolium* where the two species mingle as on the Waimarino Plains (× *D. vulcanicum*) and also with *D. lessonianum* (× *D. marginatum*).

Distribution.—From the middle Waikato and Upper Thames Valleys and Rotorua to Ruapehu, the Kaimanawa and Ruahine Ranges. It is dominant over large areas on the Rangitaiki Plains. (Specimens examined)—Te Waotu, Mangapeehi, Rotorua, Patetere Plateau, Lake Tarawera, Taupo, Rangitaiki Plains, Tongariro, Ruapehu, Waiotapu, Waimarino Plains, Kaimanawa Range, Ruahine Range, Mount Blowhard (Hawkes Bay), Kuripapanga (Hawkes Bay). (Recorded)—Tarawera, Cambridge, Matamata.

Group of *D. Kirkii.*

Prostrate shrubs with broad grass-like ribbed leaves, and flowers either solitary or in few-flowered racemes. The two species included in this group are almost identical in appearance, but *D. Kirkii* has the leaves glabrous and the flowers solitary, while *D. pubescens* has pubescent leaves and flowers in few-flowered racemes. Their area of distribution extends through Nelson, North Westland and West Canterbury, *D. Kirkii* occupying the whole range while *D. pubescens* is found only in a restricted area to the North of the Lower Buller River.

The life history of *D. pubescens* might indicate an origin for the group of *D. Kirkii* from acicular leaved species as in the group of *D. minimum.* On this hypothesis *D. pubescens* would have advanced a stage further than *D. Kirkii.*

Dracophyllum Kirkii Berggren.

Dracophyllum Kirkii Berggr. *Journ. Bot.* 17, 104, 1880. Cheeseman *Man. N.Z. Fl.* 708, 1925. *D. uniflorum* Berrgr. *Minn. Fisiog. Sall. Lund.* 15, pl. 4, 1877 (not Hook. f.).

Characters.—The distinctive characters are the prostrate habit, broad glabrous grass-like leaves, and solitary flowers. Leaf sheath 4-5 mm., lamina 20-35 mm. long, 2-4 mm. broad. Corolla-tube 5 mm. long.

Forms.—Specimens from southern localities (Copland River, Black Birch Creek, Hooker Valley) have leaves narrower, 1.5-2.5 mm. broad, than those from more northern districts, 4-4.5 mm. broad, these in this character approaching *D. pubescens.*

Hybrids.—In the Arthurs Pass district hybrids between *D. Kirkii* and *D. pronum* have been detected where the two species are growing together in open scrub (× *D. saxicolum*).

Distribution.—South Nelson, North Westland, West Canterbury from 800-2,000 m. altitude. (Specimens examined)—Mountains above Arthurs Pass, Rangi Taipo, Kellys Hill, Griffin Range, Ashburton Mountains, Copland River, Black Birch Creek, Hooker Valley. (Recorded)—Lake Tennyson, Mount Torlesse.

Dracophyllum pubescens Cheeseman.

Dracophyllum pubescens Cheesem. *Man. N.Z. Fl.* 426, 1906; 2nd Ed. 708, 1925.

Characters.—Characterized by its semi-prostrate habit, its broad pubescent grass-like leaves and its flowers in few-flowered racemes. The flowers are occasionally solitary. Leaf-sheath 6 mm., lamina 45-50 mm. long, 4-8 mm. broad. Corolla-tube 5 mm. long.

In the young plant the first leaves are acicular, 4-5 mm. long, and about .5 mm. wide. These persist on lateral branches near the base. The next leaves are broad, like the mature leaves but smaller, blade 22 × 2.5 mm. From this position the leaves increase in size up the stem until they become larger than the mature leaves.

Distribution.—On mountains to the north of the lower Buller Valley, 500-1,000 m. altitude. (Specimens examined)—Mount Rochfort, Mount Frederic, Mount Augustus, Burnetts Face.

Group of *D. scoparium.*

Erect shrubs on trees, with narrow, ciliolate leaves. Flowers in few-flowered racemes with persistent bracts, or solitary. The flowers are small, corolla-tube 4 mm. *D. scoparium* from Campbell Island and *D. paludosum* from Chatham Island are closely allied and if growing on the same island could scarcely have been defined. *D. arboreum* from Chatham Island is evidently an ally though differing from the other two in its larger wider leaves and distinct juvenile form. The group is not represented on the main islands of New Zealand, but it approaches nearest the group of *D. rosmarinifolium.*

Dracophyllum scoparium Hook. f.

Dracophyllum scoparium Hook. f. *Fl. Ant.* 1, 46, Pl. 33 (except capsule and seed), 1844. Campbell Id. Cheeseman *Man. N.Z. Fl.* 706, 1925. *D. Urvilleanum* var. *scoparium* Hook. f. *Handb. N.Z. Fl.* 736, 1867. *D. subantarcticum* Cockayne, *Veg. N.Z.* 265, 1921 (name only). *D. Urvilleanum* Filhol *Miss. Ile Camp. Bot.* 6, 1885 (not A. Rich). *Dracophyllum* sp. Cockayne, *Trans. N.Z. Inst.*, 36, 271, 1904.

There has been a certain amount of confusion in the nomenclature of this species owing to Hooker associating it with *D. Urvilleanum*, to which it bears little resemblance, and to the plate in the *Flora Antarctica* not quite representing the species but partly showing the habit of *D. arboreum*. Through the courtesy of the Director of the Kew Herbarium I have been enabled to examine a portion of the type specimen and it is undoubtedly the species that grows abundantly in Campbell Island. Botanists finding the common *Dracophyllum* on Campbell Island in some respects unlike the plate in the *Flora Antarctica* which they naturally took to represent the species described by Hooker were doubtful as to the correct name to be applied to it. The Director of the Kew Herbarium informs me, however, that the description and figures in the original account, with the exception of the capsule and seed and probably the habit figure, which are based on Chatham Island material, refer to the species herein delimited.

Characters.—An erect shrub, 2 m. tall, with dense foliage. Leaves narrow, 30-60 mm. long, 1 mm. wide, tomentose above. Flowers solitary or in few-flowered racemes. Sepals and bracts with white ciliate margins and pubescent within near the tips. *D. scoparium* is very closely allied to *D. paludosum* differing mainly in the longer narrower leaves which are tomentose above instead of being ciliate only on the margins as in *D. paludosum*.

Hybrids.—*D. scoparium* crosses freely with *D. longifolium* with which it associated on Campbell Island, producing a series of intermediate forms (× *D. insulare*).

Distribution.—Campbell Island, forming the principal constituent of the scrub.

Dracophyllum paludosum Ckne.

Dracophyllum paludosum Cockayne, *Trans. N.Z. Inst.* 34, 318, 1902. *D. scoparium* var. *paludosum* Cheeseman *Man. N.Z. Fl.* 707, 1925. *D. rosmarinifolium* Buchanan, *Trans. N.Z. Inst.* 7, 338, 1875 (not Forst.).

Characters.—A shrub which in its flowering state varies from a few cm. to 2 m. tall. Leaves narrow, 30-40 mm. long, 1-1.5 mm. wide, the margins minutely ciliated. Flowers solitary or in few-flowered racemes. Sepals and bracts with pale ciliate margins. In a flowering plant 15 cm. tall, which I collected in a swamp on Chatham Island the flowers were all solitary, each one subtended by a few leaf-like bracts.

Distribution.—Chatham Island, chiefly in swamps.

Dracophyllum arboreum Ckne. (Fig. 5.)

Dracophyllum latifolium var. *ciliolatum* Hook. f. *Handb. N.Z. Fl.* 736, 1867. *D. arboreum* Cockayne, *Trans. N.Z. Inst.* 34, 318, 1902. Cheeseman *Man. N.Z. Fl.* 707, 1925. *D. scoparium* Mueller, *Veg. Chatham Id.* 42, 1864 (not Hook. f.).

D. scoparium var. *major* Cheeseman, *Man. N.Z. Fl.* 425, 1906.

This species was first described by Hooker under the varietal name *ciliolatum*. It would be in accordance with the principle of the law of priority to use this name for the species, but in deference to a rule in the same code I adopt the name *arboreum*. As showing the complexity of the code Cheeseman bestowed a third name *major* under the impression that he was abiding by the rules.

Characters.—A shrub or small tree, up to 10 m. tall. Leaves with densely-ciliate margins, and at the base pubescent above. Juvenile leaves large, 120-180 mm. long; mature leaves 80 mm. long. Flowers in racemes with broad persistent bracts with ciliate margins; corolla-tube 5 mm. long. This species looks different from *D. scoparium* and *D. paludosum* but the disposition of the cilia on the leaf-margins seems to ally it to the group of *D. scoparium*, as a member which has advanced considerably in size, diversity of leaf and definiteness in the raceme.

Distribution.—Chatham Island.

Group of *D. Urvilleanum*.

Erect shrubs or trees. Leaves long, very narrow, hollowed above, except at the tip, more or less of which is flat above. Flowers in racemes with the bracts persistent or deciduous.

This group includes those species of *Dracophyllum* which have long, very narrow leaves and flowers in racemes. Two, *D. Urvilleanum* and *D. filifolium*, are very closely allied, and in their partly deciduous bracts approach the group of *D. longifolium*. *D. collinum* is related to *D. Urvilleanum*, but has a longer flower, and long persistent bracts. *D. Lessonianum* is quite distinct from the other species by reason of tis long sepals and clustered racemes.

D. Urvilleanum and *D. collinum* occupy different districts in the north of the South Island, *D. filifolium* is found over most of the North Island south of latitude 38° S., while *D. Lessonianum* is only found to the north of this line. Such a type of distribution, that is, species occupying adjacent but indistinct areas is not uncommon for related species.

Dracophyllum Urvilleanum A. Rich. (Fig. 6.)

Dracophyllum Urvilleanum Richard, *Voy. Astrol. Bot.* 221, 1832.

The accounts published under this name are in such utter confusion that it is useless to quote any further references. It is in fact quite impossible to tell what form is meant when the name *Urvilleanum* is used in botanical publications.* It has been applied not only to 3 of the species in the group of *D. Urvilleanum* as here defined but also to other species such as *D. scoparium*, and *D. longi-*

FIG. 1—*Dracophyllum minimum* F. v. Muell
Erect and prostrate forms. Tasmania

FIG 2.—*Dracophyllum pronum* W. R. Oliv. Mount Ida.

FIG. 3.—*Dracophyllum politum* (Cheesem.) Ckne.
Rakiahua, Stewart Island.

Fig. 4.—*Dracophyllum rosmarinifolium* (Forster) R. Br. Ben More.

FIG 5—*Dracophyllum arboreum* Ckne Juvenile and adult
Chatham Island.

FIG 6—*Dracophyllum Urvilleanum* A Rich. Adult and juvenile
Astrolabe Bay.

a b

. 7 —a. *Dracophyllum collinum* W. R. Oliv Tinline Valley.
b. *D. longifolium* (Forst.) R Br. Mount Rochfort

FIG 8.—*Dracophyllum squarrosum* Hook. f. Adult and juvenile. Waitemata Harbour.

FIG 9—*Dracophyllum patens* W R Oliv Mount Hobson, Great Barrier Island.

FIG. 10.—*Dracophyllum viride* W. R. Oliv. Spirits Bay.

FIG. 11.—× *Dracophyllum varium* Col Ruahine Range.

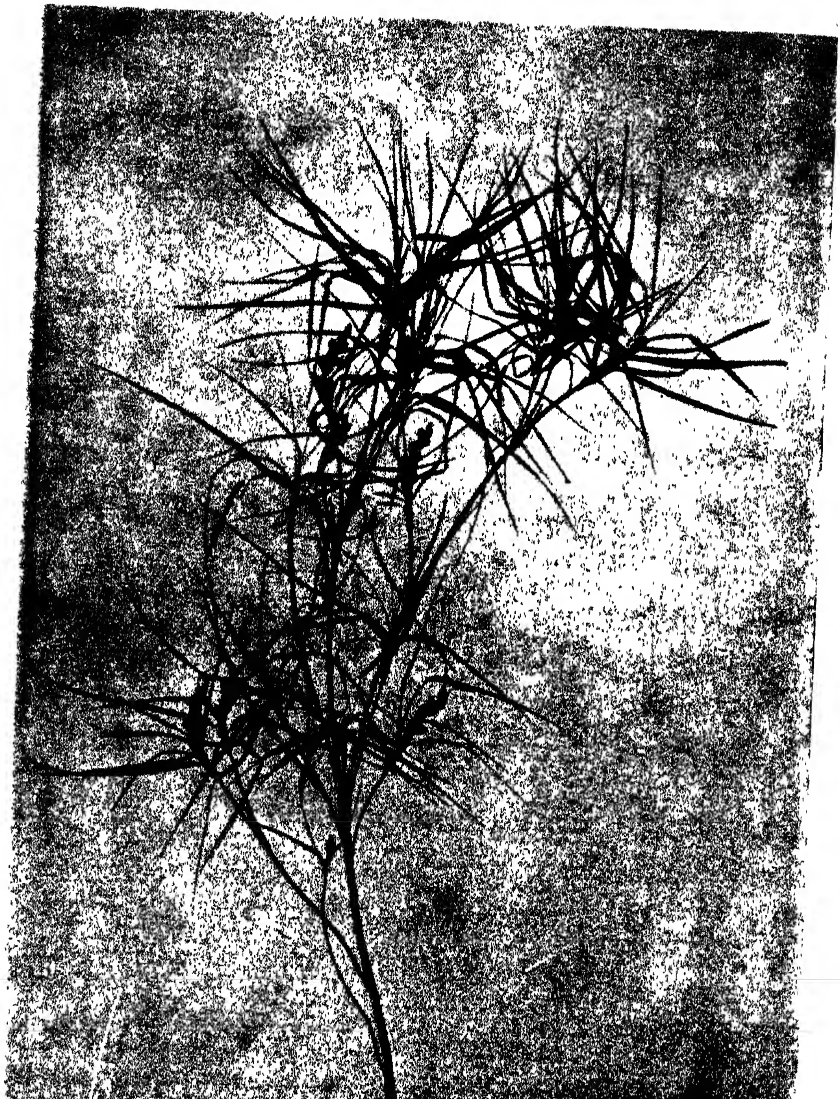


FIG. 12.—*Dracophyllum Adamsii* Petrie. Awatere River.

FIG. 13 —× *Dracophyllum heterofloium* W. R. Oliv. Hooker Valley.

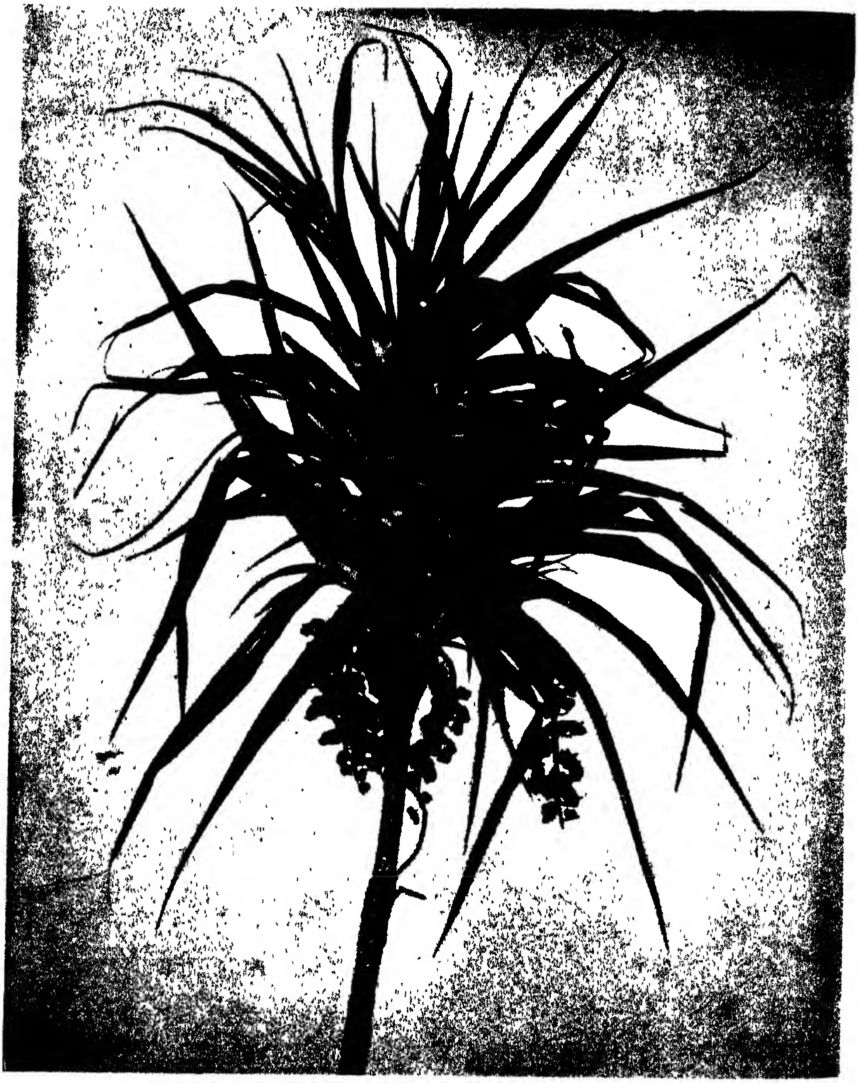


FIG. 14.—*Dracophyllum Menziesii* Hook. f. Dusky Sound.

Fig. 15.—*Dracophyllum fiordense* W. R. Oliv. Wilmot Pass.

FIG 16—*Dracophyllum strictum* Hook. f Waiotapu.

FIG. 17—*Dracophyllum ramosum* Br & Gris New South Wales

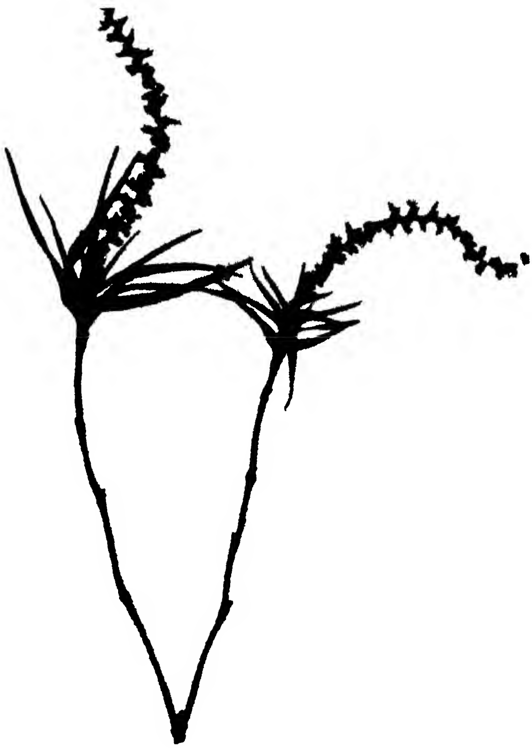


FIG 18—*Dracophyllum amabile* Br & Gris New Caledonia

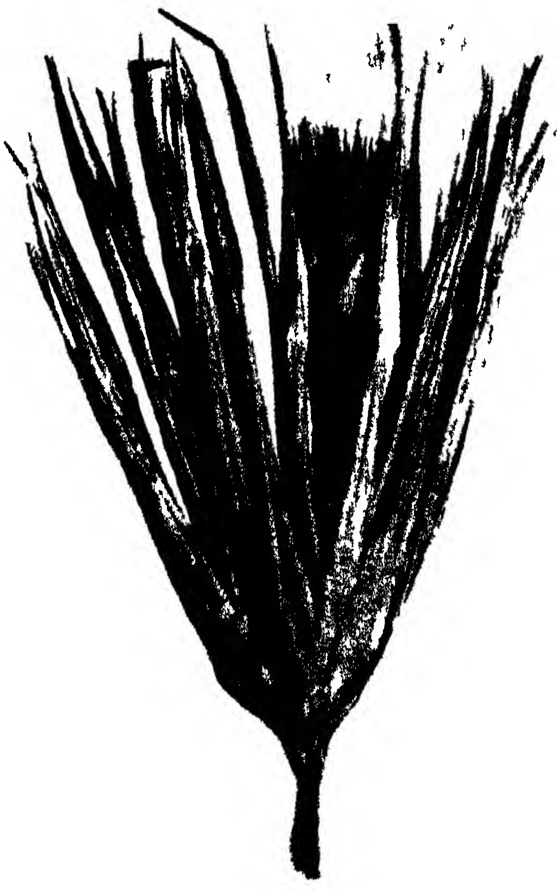


FIG 19.—*Dracophyllum Sayeri* F v Muell
Bellenden Ker Range, Queensland

FIG. 20.—*Dracophyllum Milligani* Hook. f. Tasmania.

FIG. 21.—*Dracophyllum Fitzgeraldi* Moore & F. v. Muell.
Lord Howe Island.

FIG. 22.—*Dracophyllum Traversii* Hook. f. Arthurs Pass.

FIG. 23.—*Dracophyllum recurvatum* Col. Little Barrier Island.

FIG 24—*Dracophyllum verticillatum* Lab New Caledonia

FIG. 25.—*Dracophyllum involucratum* Br. & Gris. New Caledonia.

folium. I am here restricting the name *Urvilleanum* to the species found on the north coast of the South Island. It was originally collected by D'Urville in Tasman Bay.

Characters.—An erect shrub. Mature leaves very narrow acicular, hollowed above, sheaths narrowing abruptly to the leaf-lamina. Leaf-sheath 6, lamina 70 mm.; width 1 mm. Juvenile leaves larger and thinner, sheath 8, lamina 120 mm.; width 3 mm. Racemes terminating short lateral branches bearing a few leaves below them; few-flowered, bracts with sheaths suddenly narrowing to an acicular point, deciduous. Sepals acute, margins sparingly ciliate. Corolla equal in length to the sepals, 5 mm., with acute lobes.

D. Urvilleanum is very closely related to *D. filifolium,* differing in the bracts narrowing regularly, that is without a shoulder, in the few-flowered racemes with deciduous bracts and in the large grass-like leaves of the juvenile plant.

Distribution.—Western shores of Tasman Bay, D'Urville Island, Picton, Tennyson Inlet.

Dracophyllum filifolium Hook. f.

Dracophyllum filifolium Hook. f. *Fl. Nov. Zel.* 1, 169, 1853. *D. setifolium* Stchegel, *Bull. Soc. N.H. Mosc.* 32, 23, 1859. *D. pungens* Colenso, *Trans. N.Z. Inst.* 28, 602, 1896. *D. virgatum* and *D. heterophyllum* Colenso, *l.c.,* p 605, 1896.

This form has been much misunderstood, Cheeseman for instance recording it as occurring from the Bay of Islands to Stewart Island. Evidently several species as defined in this paper are involved in this conception.

Characters.—A shrub or small tree. Leaves very long and narrow, 130-160 mm. long, 1 mm. wide, hollowed above except near the tip, sheath 10-15 mm. long. Racemes narrow terminating slender lateral branches with a few leaves below them, 7-9 flowered; bracts usually persistent, the sheath narrowing abruptly to the tip. Sepals equal in length to the corolla-tube, margins ciliate, 5 mm.

Compared with *D. Urvilleanum,* which is its nearest ally, this species differs in its racemes having more flowers with persistent bracts and in the slightly different form of the bracts. Usually the leaves are longer than in *D. Urvilleanum* and the racemes are longer and narrower.

Forms.—Differences are observed when specimens from different localities and habitats are compared. The leaves of plants from the Tararua Ranges are very long, reaching 160 mm.; those from plants from the Waimarino Plains are considerably shorter, the longest being about 100 mm.

Hybrids.—*D. filifolium* hybridizes freely with *D. recurvum* (× *D. arcuatum*), and with *D. subulatum* (× *D. vulcanicum*).

Distribution.—From Mount Egmont, Mount Ruapehu, and the Ruahine Range southwards to Cook Strait, ascending to 4,500 feet. (Specimens examined)—Mount Egmont, Mount Ruapehu, Waimarino Plains, Ruahine Range, Mount Holdsworth, Mount Marchant, Mungaroa.

Dracophyllum collinum n. sp. (Fig. 7a.)

Frutex erectus; foliis augustatis, subulatis, 80-100 mm. longis, 1.5 mm. latis; floribus racemosis, 6 mm. longis, bracteis persistenbibus, sepalis acumuatis. Type locality, Tinline Valley, Marlborough.

I have seen this species only from one locality, but it does not resemble any species or hybrid with which I am acquainted, so I am describing it as a new species.

Characters.—Evidently a slender erect shrub. In the specimens examined the shoot extends 25 cm. beyond the cluster of racemes. Leaves narrow but sufficiently wide at the base to describe them as subulate; widening abruptly into the sheath. Racemes terminating short lateral branches with a few leaves below them, 8-10 flowered. Corolla rather long, 6 mm. Bracts persistent, large, with long points, the sheath narrowing gradually to the point.

D. collinum is placed in the group of *D. Urvilleanum* because of its narrow leaves. They are, however, slightly wider at the base than in the mature leaves of *D. Urvilleanum* or *D. filifolium*. The sheath is shouldered but not auricled above. The racemes are larger, the corolla-tube longer, and the bracts wider than in *D. Urvilleanum.* The sepals also are longer and more acuminate than in *D. Urvilleanum.*

Distribution.—Tinline Valley, Marlborough.

Dracophyllum Lessonianum A. Rich.

Dracophyllum Lessonianum A. Rich. *Voy. Astrol. Bot.* 223, 1832. Homb. & Jacq. *Bot. Voy. Astrol. & Zel.* 85, pl. 29, 1853. *D. robustum* Hook. f. *Fl. Ant.* 1, 49, 1844.

References in literature to this species, or variety of *D. Urvilleanum* as it has sometimes been classed, are quite confusing, more than one form evidently being included. Thus the range given in Cheeseman's *Flora,* namely, Rotorua to Stewart Island, is wholly outside its area of distribution as given in this revision. Nor could such a distributional area be correct, as Richard's specimens probably came from the Bay of Islands, which is one of the localities in which Lesson collected during his visit to New Zealand in the Astrolobe. Hooker (*Handb. N.Z. Fl.* p. 182, 1864) gives the distribution of *D. Lessonianum* as north of Auckland only.

Characters.—A shrub or small tree 10 m. tall. Leaves narrow, 60-100 mm. long, 1 mm. wide, hollowed above for more than half the distance from the base; sheath auricled. Racemes long, terminating short lateral branches, clustered towards the ends of the branches; bracts, persistent, with long narrow sheaths; sepals acuminate, slightly exceeding the corolla-tube; corolla-tube long, 6 mm. The juvenile leaves are wider than the mature leaves, lamina length 60 mm., width 3 mm.

D. Lessonianum is easily distinguished from the other members of the group by tis generally shorter leaves, but especially by the long racemes, with long acuminate sepals and long flowers; the bracts with narrow sheaths are also characteristic. The dense clusters of racemes gives the plant a distinct appearance.

Forms.—In Mr. Carse's herbarium are specimens from the same locality (Pukemiro) which show considerable differences in size. In one the leaf is 100 mm. and the flower 6 mm. long; in another the leaf is 50 mm. and the flower 4 mm. long, but what status should be given these forms I am unable to decide.

Hybrids.—At Tauhei (Piako County) it hybridizes with *D. subulatum* (× *D. marginatum*); in the Mangonui County it crosses with *D. squarrosum* (× *D. densiflorum*).

Distribution.—Auckland Province north of S. Lat. 38°. (Specimens examined)—Kaitaia, Mount Camel, Pukemiro, Kaimaumau, Fairburn, Maropui (Kaihu Valley), Whangarei, Great Omaha, Bay of Islands, Tauhei (Piako), Te Aroha.

× **Dracophyllum vulcanicum** n. hybr. sp.
(*D. filifolium* × *D. subulatum.*)

Frutex erectus, gracilis; foliis filiformis 40-50 mm. longis; basis auriculatis; racemis paucifloris, lateralibus, bracteis angustatis.

Characters.—This form is found in association with *D. filifolium* and *D. subulatum.* Its characters are a combination of some from each of these species, so that it is with little doubt a hybrid between them. It is a slender strict shrub, much like *D. subulatum.* Its leaves are very narrow, like those of *D. filifolium,* but they are much shorter, no doubt due to the influence of *D. subulatum.* The flowers, like those of *D. subulatum,* are small and solitary or in few-flowered racemes. Bracts with narrow sheaths, and light-coloured margins.

Distribution.—Waimarino Plains, Ngauruhoe.

× **Dracophyllum marginatum** n. hybr. sp.
(*D. Lessonianum* × *D. subulatum.*)

Frutex gracilis; ramis tennibus; foliis filiformis; basis truncatis; racemis paucifloris, lateralibus vel terminalibus.

Characters.—The plants grouped under this hybrid look very different, but agree in being slender shrubs with short filiform leaves, and short few-flowered racemes of small flowers. The leaf sheaths are like those of *D. Lessonianum,* that is, narrower and not auricled on those leaves near the tips of the branchlets but auricled on leaves lower down, and they have whitish margins. The lamina may not be longer than in *D. subulatum* but is shorter than in *D. Lessonianum* and has the large sheaths of *D. Lessonianum.* The racemes are much as in *D. subulatum,* but are clustered and terminate the branches as in *D. Lessonianum.*

The plants examined were all collected at Tauhei, Piako County, by Mr. H. Carse, in association with *D. Lessonianum* and *D. subulatum.* There can scarcely be any doubt that they are hybrids between these species. They resemble quite closely × *D. vulcanicum* the hybrid between *D. filifolium* and *D. subulatum.*

Distribution.—Tauhei (Piako County, New Zealand).

Group of *D. squarrosum.*

This group is characterized by its broad leaves, and lateral racemes with persistent bracts. The adult leaves are moderately short, but the juvenile leaves may be long. The group stands between

those of *D. Urvilleanum* and *D. longifolium,* which latter group it resembles in the acute sepals with ciliate margins and large juvenile leaves. One species (*D. viride*) is easily separated from the others by its thin leaves and lax racemes; of the other two, *D. patens,* has much broader leaves than *D. squarrosum.* All the species are confined to New Zealand north of S. Lat. 38°, one being restricted to the far north, and another to Great Barrier Island.

Dracophyllum squarrosum Hook. f. (Fig. 8.)

Dracophyllum squarrosum Hook. f. *Fl. Ant.* 1, 48, 1844. Manukau Bay. *D. Sinclairii* Cheeseman, *Man. N.Z. Fl.* 421, 1906; *2nd Ed.* 704, 1905

Under Article 50 of the International Rules of Botanical Nomenclature, Cheeseman would not be justified in rejecting *squarrosum* and founding the new name *Sinclairii* on account of the prior *Dracophyllum squarrosum* Brown, as this species was described as *Epacris squarrosa* by Poiret, was later transferred to *Sphenotoma* by Don, and at the time Cheeseman wrote was accepted as belonging to *Sphenotoma.* Brown's classification was not generally accepted. *Sphenotoma* is retained in De Candolle's *Prodromus* and Mueller's *Fragmenta.*

Characters.—The distinctive characters of *D. squarrosum* are the short moderately broad leaves of the mature plant, the large leaves of the juvenile plant, and the clustered racemes terminating short lateral branches. The sepals are acute with sparsely-ciliate margins and longer than the corolla-tube. The corolla-tube is short, 4 mm. The sheaths of the leaves are not distinctly auricled but join the lamina abruptly. The young leaves reach a length, including the sheath, of 150 mm., with a width of 7 mm. just above the sheath. Adult leaves measure 60 mm. in length and 3 mm. in breadth.

Distribution.—New Zealand north of S. Lat. 38° 30′. (Specimens examined)—Reef Point, Waitemata Harbour, Thames, Tapotopoto Bay, Mount Messenger.

Dracophyllum patens n. sp. (Fig. 9.)

Frutex parvus; ramis robustis; foliis, latis, brevibus, 45 mm. longis, 6.5 mm. latis, crassis, subulatis; racemis, paucifloris, bracteis sepalisque latis.

Characters.—The leaves resemble very closely those of *D. strictum,* but the lateral racemes ally the species to *D. squarrosum.* Leaves short, broad at the base, narrowing gradually to the apex; at the base they widen suddenly to the broad sheath which has thin scarious margins. Sheath 8 mm. long, 1 mm. wide, lamina 38 mm. long, 6.5 mm. wide at base. Racemes short stout, 5-6 flowered. Bracts with broad sheaths and short broad points. Sepals broadly acute, a few cilia on the margins near the base. Corolla-tube wide, 4 mm. long.

The nearest ally of this species is *D. squarrosum,* but it differs in being stouter in all its parts. The leaves of *D. patens* are about twice as wide as those of a similar length in *D. squarrosum.* I have seen no specimens of *D. squarrosum* from the mainland approaching it, hence I conclude that it is not a habitat form of that species.

Distribution.—Great Barrier Island, in scrub at summit of Mount Hobson.

Dracophyllum viride n. sp. (Fig. 10.)

Frutex vel arbor, ramis gracilibus; foliis, tenuibus, latis, viridibus; racemis, laxis, paucifloris, sepalis, acutis, bracteis attenuatis.

Characters.—Easily distinguished from all other species of *Dracophyllum* by its thin, broad, grass-like leaves, and few lax racemes immediately below the tufts of leaves which terminate the branches. According to Mr. Carse it is a small tree 3.5 m. tall, with a trunk 10-23 cm. in diameter. The ultimate branches are very slender and bear at their tips the long green leaves. The racemes are few, and consist of 5 to 6 flowers separated by short intervals on a slender rhachis. Bracts narrow, thin, acuminate. Sepals narrow, acuminate, with a few marginal cilia. Corolla-tube short, 4 mm.

Juvenile leaves reach a length of 175 mm. (including the sheath), and a width of 8 mm. Mature leaves 60-70 mm. long, 5-6.5 wide.

Distribution.—Mangonui County, North New Zealand. (Specimens examined)—Spirits Bay, Peria. (Petric referred the Peria specimens to his *D. Adamsii*), Tauroa.

× **Dracophyllum densiflorum** n. hybr. sp.
(*D. Lessonianum* × *D. squarrosum.*)

Frutex; ramis tenuibus, apexes multo divisis; foliis subulatis, complanatis basis varginantis vix auriculatis; racemis paucifloris, ramos laterales ad apexes; bracteis sepalisque ciliatis.

Characters.—This form is recognized by the dense foliage, few-flowered racemes terminating slender lateral branches and sometimes the main branches, small flowers with ciliate bracts and sepals, and moderately narrow short leaves.

In the clustered racemes of narrow flowers this form resembles *D. Lessonianum*, but the corolla-tube and sepals are short as in *D. squarrosum*. The leaves resemble those of *D. squarrosum* but are narrower, showing the influence of *D. Lessonianum*. I conclude therefore that it is a hybrid between the two species. It comes within the geographical range of both these species, though I am unable to state definitely that in the localities in which it is found it is immediately associated with them.

Leaves 30-50 mm. long, including the sheath, 5 mm. width at base 1-1.5 mm. Sepals acuminate, ciliate, longer than the corolla-tube, 5-6 mm. Corolla-tube 4-5 mm. Racemes 7-8 flowered bracts narrow.

Distribution.—Awanui, Rangaunu Harbour (both localities in Mangaonui County, New Zealand).

Group of *D. recurvum.*

Prostrate shrub with recurved leaves and short dense terminal racemes with persistent bracts. In the shape of the leaf it comes near the group of *D. squarrosum,* but the terminal racemes separate from all groups of the subgenus *Oreothamnus*. A single species only, found in the central portion of the North Island is included.

Dracophyllum recurvum Hook. f.

Dracophyllum recurvum Hook. f. *Fl. Ant.* 1, 50, 1844 (Tongariro). Cheeseman *Man. N.Z. Fl.* 704, 1925; *Ill. N.Z. Fl.* pl. 131, 1914. *D. rubrum* Col. *Trans. N.Z. Inst.* 20, 200, 1888. *D. tenuicaulis* Col. *l.c.* 22, 476, 1890. *D. brachyphyllum* Col. *l.c.* 28, 604, 1896. *D. brachycladum* Col. *l.c.* 31, 275, 1899.

Characters.—The species is easily recognized, the recurved leaves and terminal racemes separating it from all other species of the genus. It is usually a low or prostrate shrub with wide-spreading branches covered with grey bark. Leaves about 20 mm. long, 1.2-1.5 mm. wide. Racemes about 1.5 mm. long, and nearly 1 cm. wide.

Habitat forms.—Growing among other shrubs *D. recurvum* may be a semi-erect shrub .5 m. tall with curved leaves 30 mm. long, but in the desert scrub of Mount Ruapehu it is a prostrate shrub a few cm. tall and with leaves 20-25 mm. long and curved to such an extent as sometimes to form more than half a circle. The leaves are reddish in such plants.

Hybrids.—*D. recurvum* crosses with both *D. longifolium* and *D. filifolium* producing hybrids (× *D. varium*, × *D. arcuatum*) which are very much alike in appearance but differ in the width of the leaves and the size of the racemes.

Distribution.—On mountains in the central and eastern portion of the North Island of New Zealand. (Specimens examined)—Mount Hikurangi, Tongariro, Ngauruhoe, Ruapehu, Mount Kakaramea, Ruahine Range, Rangipo Plain. (Recorded)—Kaimanawa Range.

× **Dracophyllum varium** Col. (Fig. 11.)
(*D. longifolium* × *D. recurvum.*)

Dracophyllum varium Col. *Trans. N.Z. Inst.* 28, 603, 1896 (Ruahine Range). *D. Urvilleanum* var. *montanum* Cheeseman, *Man. N.Z. Fl.* 424, 1906. *D. montanum* (Cheeseman) Cockayne, *Veg. N.Z.* 218, 1921. *D. Urvilleanum* var. *scoparium* Adams, *Trans. N.Z. Inst.* 30, 426, 1898 (not A. Rich.).

Dracophyllum varium of Colenso as shown by the type specimen in his herbarium is a hybrid between *D. recurvum* and *D. longifolium.* On hybrids of the same parentage Cheeseman founded the name *montanum*, his specimens coming from Mount Hikurangi.

Characters.—The prevalent form of this hybrid is a low shrub, with stiff, straight or recurved leaves, 40-60 mm. long, 2-3 mm. wide at the base, and terminal racemes with rather large flowers. The leaves are like those of *longifolium* but shorter and often recurved. The racemes are intermediate between those of *recurvum* and *longifolium*, but like those of *recurvum* terminate the main branches as well as the lateral ones.

Distribution.—On mountains in the central and eastern portion of the North Island of New Zealand. (Specimens examined)—Mount Hikurangi, Ruahine Range, eastern base of Ruapehu, Waiotapu.

× **Dracophyllum arcuatum** n. hybr. sp.
(*D. filifolium* × *D. recurvum.*)

Frutex parvus; foliis brevibus, subulatis, arcuatis basis vaginantis truncatis; racemis paucifloris terminalibus, floribus parvis.

Characters.—A small erect shrub, with short, stiff, rather narrow leaves, often slightly recurved, and few-flowered racemes terminating the branches. These characters are undoubtedly produced by the crossing of *D. filifolium* and *D. recurvum.* The leaves are 30-40 mm. long, and about 2 mm. wide just above the sheath. The panicles are few-flowered and small, like those of *D. filifolium* but are terminal, a character due to the influence of *D. recurvum.* The above description is based on specimens collected on Mount Ruapehu where this hybrid grows in association with *D. recurvum* and *D. filifolium.* Forms midway between these two species naturally attract attention but on close collecting it is found that there is a graded series between the two parent forms.

Distribution.—Ruapehu and Ruahine mountain ranges. (Specimens examined)—Mount Ruapehu, Waimarino.

Group of *D. longifolium.*

Tall shrubs or trees. Leaves long, flat, moderately narrow and with a wide sheath. Racemes with the bracts falling early, terminating lateral branches. The character of the raceme coupled with that of the leaves distinguishing this group. The raceme has advanced to the stage of losing the bracts early. The flowers are stalked and the whole raceme may droop, thus resembling in appearance the simple panicles of the subgenus *Eudracophyllum.* I regard this type of raceme as the most specialized in the subgenus *Oreothamnus*; of the two species belonging to the group, *D. longifolium* has stiff leaves, *D. Adamsii* has thin flaccid leaves. *D. longifolium* ranges from the East Cape to Campbell Island, while *D. Adamsii* is restricted to the Bay of Plenty and East Cape districts.

Dracophyllum longifolium (Forst.) R. Br. (Fig. 7b.)

Epacris longifolia Forst. *Char. Gen.* 20, pl. 10, 1776. *E. frondosa* Gaertner, *Fruct. Sem. Pl.* 2, 77, 1788. *Dracophyllum longifolium* R. Br. *Prodr. Fl. Nov. Holl.* 556, 1810. Hook. f. *Fl. Ant.* 1, 48, pl. 31, 1844. Homb. & Jacq. *Bot. Voy. Astrol. Zel.* 86, pl. 27, 1853. Cheeseman *Man. N.Z. Fl.* 704, 1925. *D. Lyallii* Hook. f. *Fl. Nov. Zel.* 1, 169, 1853. *D. longifolium* var. *retortum* Homb. & Jacq. *Bot. Voy. Astrol. & Zel.* 86, 1853.

D. longifolium varies somewhat in the size of the leaf so that in botanical literature it has been many times recorded as one of the varieties of *D. Urvilleanum.*

Characters.—The constant characters by which this species is recognized are the long, stiff, narrow leaves, and the racemes with bracts that fall early. The loss of the bracts gives the raceme a distinct appearance resembling the simple panicle of the subgenus *Eudracophyllum.* This appearance is the more noticeable on account of the fact that the raceme is often drooping. The leaves, as

described below, vary very much in length, width, and stiffness, but all agree in being flattened at the base and in having the sheath wide and truncate or auricled above. *D. longifolium* may be a shrub 1 m. tall or a tree 12 m. tall. It is largest in the southern portions of its range.

Forms.—In different localities and habitats various differences are seen in the life-form of this species, in the racemes, and in the leaves. I do not regard all these differences as due to the environment, hence the species is compound; though on the material available I am not able satisfactorily to divide it into either genetic or habitat forms.

Possibly the three following forms are genetically distinct.

(1) Broad-leaved form from Auckland and Campbell Island. Leaves broad, stiff and spear-like, with broad sheaths. Racemes erect. Leaf from Campbell Island—sheath 18 × 14 mm., lamina 125 × 5 mm. Specimens with short leaves, evidently a habitat form, were described by Hombron and Jacquinot as variety *retortum.*

(2) Prevalent form in New Zealand. Leaves long, narrow, moderately stiff. Racemes often drooping. Leaf from small tree in beech forest, Lake Manapouri—sheath 14 × 8 mm., lamina 130 × 2 mm.

The life-form for the most part accords with the habitat. In forests it is arborescent with long leaves; in bogs and exposed alpine localities it is a shrub with short leaves. The flowers are larger in the forest forms.

(3) Short-leaved form from alpine and swampy localities. Leaves short, narrow. Racemes erect, clustered. Leaf from Mount Rochfort—sheath 5 mm., lamina 40 × 1.5 mm. Similar forms come from Eweburn Creek, Upper Hawera, Mount Arthur Plateau and swamps near Lake Manapouri. (Fig. 7b.)

Hybrids.—*D. longifolium* freely crosses with several species with which it comes in contact. It produces hybrids with *D. scoparium* on Campbell Island (× *D. insulare*); with *D. rosmarinifolium* throughout the South Island (× *D. acicularifolium*) and with *D. recurvum* in the North Island (× *D. varium*).

Distribution.—From the East Cape district southward to Campbell Island. (Specimens examined)—Awatere River, Mount Hikurangi, Ruahine Range, Mount Marchant, Dun Mountain, Mount Arthur, Buckland Peaks, Mount Rochfort, Wangapeka, Kellys Hill, Arthurs Pass, Hooker Valley, Eweburn Creek, Upper Hawea, Mount Peel, Lake Harris, Tapanui, Swampy Hill, Stewart Island, Auckland Islands, Campbell Island.

Dracophyllum Adamsii Petrie. (Fig. 12.)

Dracophyllum Adamsii Petrie *Trans. N.Z. Inst* 55, 435, 1924 (Awatere River).

Characters.—This species is at once recognized by the narrow, thin, flat leaves and slender racemes with short acute sepals ciliate to the tips and with early deciduous bracts. The racemes with deciduous bracts and the narrow flat leaves ally it to *D. longifolium,* but the leaves are much thinner than in that species and do not stand

up so stiffly; the flowers are smaller, and have short, broad, acute, thin sepals, ciliate along the margins to the tipe. The ultimate branches are very slender and each terminates in a raceme subtended by a cluster of leaves. Leaf sheath with hyaline margins, truncated distally. Leaf sheath 8 × 5 mm., lamina 65 × 2.5 mm. Raceme 30 mm., sepals 4 mm.

Distribution.—Kennedy Bay, Inland from Opotiki, Awatere River (Waiapu County).

× **Dracophyllum acicularifolium** (Cheesem.). (Fig. 13.)
(*D. rosmarinifolium* × *D. longifolium.*)

Dracophyllum uniflorum var. *acicularifolium* Cheeseman, *Man. N.Z. Fl.*, 427, 1906. *D. acicularifolium* Cockayne, *Rep. Scenery Pres. Soc.* 4, 1915.

This identification is based on the result of a comparison of the specimens arranged under *D. acicularifolium* in the Cheeseman and Petrie herbaria, with a series of hybrids between *D. rosmarinifolium* and *D. longifolium* from Arthurs Pass. Only those specimens with narrow leaves agreeing with those on which Cheeseman's diagnosis was based are in doubt, but one of the specimens from Arthurs Pass exactly matches a specimen from Castle Hill in the Cheeseman herbarium. This specimen may be taken as the type of Cheeseman's *acicularifolium* as it corresponds to his description and comes from near the only locality definitely named by him, namely, the Broken River Basin.

Characters.—The prevalent form of this hybrid is that which has solitary flowers like those of *D. rosmarinifolium* and leaves intermediate between those of *D. rosmarinifolium* and *D. longifolium.* In specimens from Hooker Valley in Cheeseman's herbarium the leaves are 60 mm. long. At Arthurs Pass where *D. rosmarinifolium* and *D. longifolium* come together, hybrids are fairly frequent. They may be recognized by the fact that solitary flowers are borne on shrubs with leaves like those of *D. longifolium,* but shorter than would be expected in the habitat. Such plants sometimes possess both solitary and racemose flowers. Some of the hybrids have leaves as narrow as in *D. rosmarinifolium* but longer and these correspond with the description of Cheeseman's variety *acicularifolium.* A form which this hybrid sometimes takes is that in which the leaves are scarcely longer than in those of *D. rosmarinifolium,* but the flowers are in racemes. Specimens answering to this description come from the Dun Mountain, the Routeburn Valley, the Longwood Range, and other places.

Distribution.—Mountain districts in the South Island, New Zealand. (Specimens examined).—Dun Mountain, Mount Arthur, Ben More, Mount Torlesse, Castle Hill, Arthurs Pass, Mount Peel, Hooker Valley, Baloon Mountain, Routeburn Valley, Longwood Range.

× **Dracophyllum insulare** n. hybr. sp.
(*D. longifolium* × *D. scoparium.*)

Frutex; foliis angustis, subulatis, supra tomentosis, 35-50 mm. longis; racemis erectis, multifloris; sepalis pubescentibus; bracteis caducis.

The existence of this form has been recognized by several botanists, hence it is necessary to quote the following references:—

D. scoparium Kirk, *Rep. A.A.A.S.* 3, 224, 1891; Cockayne *Trans. N.Z. Inst.* 36, 322, 1904 (not Hook. f.).

Characters.—Leaf narrow, subulate, pubescent above; sheath suddenly narrowed above but not auricled. Flowers in erect racemes with deciduous bracts; sepals pubescent within towards the tip. Leaf-sheath 9 mm., lamina 35-40 mm. long, 1.5 mm. wide. The pubescence of the leaves and sepals is a character of *D. scoparium* but the leaves are longer and wider than in that species. The racemes with deciduous bracts is a character of *D. longifolium*, and the influence of this species is seen in the width and length of the leaves.

Possessing characters intermediate between *D. longifolium* and *D. scoparium*, and growing in association with them, this plant is without doubt a hybrid between them.

Distribution.—Campbell Island. (Specimens examined include those collected by Kirk, Cockayne, and myself.)

Subgenus *Eudracophyllum* Benth & Hook.

Eudracophyllum Benth & Hook. *Gen. Plant.* 2, 618, 1876. Type *D. verticillatum* Lab.

Flowers in panicles. Sepals acute and equal to the length of the corolla or obtuse and short. Panicles terminal or lateral.

The only character common to the members of this subgenus is the panicled inflorescence. Different species-groups, however, show advance in structure in other organs. For instance the sepals become short and obtuse and therefore less like the foliage leaves of the primitive species, and the corolla becomes short and the stamens far exserted. Differentiation has especially taken place in the bracts which may be broad and short as in *D. strictum* or greatly elongated as in *D. Milligani.* In the group of *D. secundum* the fascicles of the panicle bear only a few flowers; in the group of *D. latifolium* they are much branched producing a compound panicle. The largest trees are found in this group and the group of *D. Milligani.*

This subgenus is to be regarded as the most advanced in organization in the genus. Its distribution is therefore of some interest. It ranges over the whole area occupied by the genus, but the greatest diversity in species occurs in New Caledonia and New Zealand. In each of these regions it is represented by seven species belonging to three groups of species. This accords with the theory already stated that the genus originated in the New Caledonian region from which centre the primitive forms have been pushed southwards towards Tasmania and New Zealand.

Altogether the subgenus contains 18 species distributed as follows:—Tasmania 1, East Australia 2, New Caledonia 7, Lord Howe Island 1, New Zealand 7.

Group of *D. Menziesii.*

Panicles borne below the terminal clusters of leaves, compound, drooping. Corolla short, stamens exserted, sepals much shorter than the corolla-tube. Leaves large, broad.

D. fiordense has the largest leaves of all the species in the genus; in *D. Townsoni* the leaves are long and narrow, in *D. Menziesii* they are broad and short. The group is not found north of Cook Strait. *D. Townsoni* occurs near the north-west coast. *D. Menziesii* is more generally distributed in mountainous regions from South Canterbury to Stewart Island, while *D. fiordense* is only known from south-west Otago.

Dracophyllum Menziesii Hook. f. (Fig. 14.)

Dracophyllum Menziesii Hook. f. *Fl. Nov. Zel.* 1, 168, 1853. Cheeseman *Man. N.Z. Fl.* 703, 1925.

Characters.—This species is to be distinguished from its allies by its low shrubby habit, crowded short and broad leaves, and rather large panicles borne on short branches below the leaves. An average-sized leaf measures 125 × 15 mm., a large specimen 170 × 17 mm.

I have seen several specimens with terminal panicles, but in all cases the branches bearing them were thin, and in cases where there were two or more branches on the same stem it was evident that the main leafy axis had been lost. Evidently therefore these branches with terminal panicles are really lateral branches which have elongated after the death of the central stem, the leaves below the panicle sharing the increase in size.

The bracts are short, broad, ovate, and suddenly contracted to a sharp point. On the small panicle-bearing branches every gradation can be found between bracts and leaves. The capsule is 5-7 valved.

Distribution.—Otago and Stewart Island, from sea-level to 1,400 m. altitude; also, according to Cheeseman, from the Ashburton Mountains in Canterbury. (Specimens examined)—Mountains above Lake Harris, Mount Bonpland, Routeburn Valley, Bold Peak, Humboldt Mountains, McKinnon Pass, Mount Barber, Lake Hauroko, Doubtful Sound, Dusky Sound, Mount Anglem (Stewart Island). (Recorded)—Ashburton Mountains, Mountains west of Lakes Wakatipu and Te Anau, Preservation Inlet.

Dracophyllum Townsoni Cheeseman.

Dracophyllum Townsoni, Cheesem. *Man. N.Z. Fl.* 420, 1906; *2nd Ed.* 702, 1925; *Ill. N.Z. Fl.* pl. 130, 1914.

Characters.—*D. Townsoni* agrees with *D. Menziesii* in its dense terminal clusters of serrulate leaves and lateral panicles. It differs, however, in the narrower and longer leaves, in the more compound panicles, and in the smaller flowers with proportionately larger corolla-lobes. Leaves 170 × 11, 260 × 14 mm. Bracts broad, contracting suddenly into subulate tips.

Distribution.—South-west Nelson and North Westland. (Specimens examined)—Mount Buckland. (Recorded)—Near Liverpool Coal Mine (Westland).

Dracophyllum fiordense n. sp. (Fig. 15.)

Frutex; caudicibus robustis haud ramosis; foliis latis, longis, canaliculatis, marginibus levibus, basis augustis, 60-70 cm. longis,

4-5 cm. latis; paniculis parvis, 12 cm. longis, multifloris, sepalis acutis, corolla parvo, antheris exsertis, capsulis parvis, 2 mm. longis, 2.5 mm. latis.

This species has been known to Mr. W. A. Thomson of Dunedin, Mr. J. Speden of Gore, and others for some years past. It was collected by Dr. G. Einar Du Rietz and myself in company with Mr. Murrell, on Wilmot Saddle and Mount Barber in March 1927, when I obtained the fruiting specimen described below. There are flowering specimens in Cheeseman's herbarium from The Hump. (Recorded in *Trans. N.Z. Inst.* 52, 11, 1920, as *D. Townsoni.*)

Characters.—A shrub 1-2 m. tall with erect stout unbranched stems marked with circular ridge-like scars, 3-4 mm. apart, of the fallen leaves. Stem 35 mm. in diameter. The leaves are the largest of all the species of *Dracophyllum* and form an immense cluster at the top of the stem. They are very broad and taper gradually to an acuminate point which often curls into a spiral. The margins are flat and smooth; the base narrows instead of widening as is usual in the genus; both surfaces are finely and regularly grooved. A mature leaf measured, length 67, breadth near base 4.8 cm.

Panicles on the stems at some distance below the leaves, 12 cm. long, curved, with a depressed rhachis giving rise to branches 2-2.5 cm long bearing numerous small flowers. Sepals ovate acute, 2.5 mm long; corolla-tube equal to the length of the sepals, with recurved lobes as long as the tube; anthers exserted; pistil long. Capsule small, 2 mm. long, 2.5 mm. across.

By virtue of its possessing panicles arising below the terminal cluster of leaves *D. fiordense* falls into the group of *D. Menziesii.* It differs from both *D. Menziesii* and *D. Townsoni* in its large leaves with smooth margins, and in its thick straight unbranched stems. The panicles are more branched than in *D. Menziesii,* but resemble those of *D. Townsoni.* The flowers are similar to those of *D. Townsoni.* The capsules are smaller than in both these species.

Distribution.—South-west Otago in scrub on the mountains between 900-1,000 m. above sea level. (Specimens examined)—Wilmot Pass and Mount Barber, The Hump.

Group of *D. secundum.*

Panicles terminal, with few flowers on their lateral branches. Corolla-tube long with anthers included (except in *D. Thiebautii,* according to its author). Leaves moderately broad and short.

The species in this group may be arranged in three sub-groups.

(1) Panicle dense, the lower branches bearing 5-9 flowers; leaves rather broad, shorter than the panicles—*D. strictum, D. ramosum.*

(2) Panicle slender, the lower branches bearing 3-5 flowers; leaves rather narrow, shorter than the panicles—*D. secundum, D. Vieillardii, D. amabile.*

(3) Panicle slender, the lower branches bearing 3 flowers; leaves narrow, exceeding the panicles—*D. gracile, D. Thiebautii.*

Of the seven species assigned to this group, *D. strictum* occurs in New Zealand, *D. secundum* in New South Wales, and the remainder in New Caledonia.

Dracophyllum strictum Hook. f. (Fig. 16.)

Dracophyllum strictum Hook. f. *Fl. Ant.* 1, 48, 1844 (Tongariro). Cheeseman *Man. N.Z. Fl.* 703, 1925. *D. affine* Hook. f. *Fl. Ant.* 1, 48. 1844. *D. Featonianum* Col. *Trans. N.Z. Inst.* 22, 477, 1890. *D. imbricatum* Col. *l.c.* 25, 331, 1893.

Characters.—The distinctive features of *D. strictum* are the usually short broad leaves, glaucous below, the moderately-dense panicles with short secondary branches and the small flowers with short sepals. Adult leaves 85 ×6, 55 × 7 mm., juvenile leaves 110 × 11, 110 × 13 mm. Corolla 4-5 mm. This species bears a great resemblance to *D. ramosum* in its habit of branching, shape of leaf, and panicle with short branches, but it is smaller in all its parts and its sepals are proportionately shorter when compared with the corolla, also the bracts are apparently less leaf-like.

Distribution.—From the Thames Firth to Ruapehu and Tarawera; also in the north-western portion of the South Island. (Specimens examined)—Puriri, Okoroire, Tirau, Tamahere, Narrows (Waikato), Waiotapu, Ruapehu, Taupo, Mount Hauhungatahi, Tarawera (Hawkes Bay), Whangaparoa, Mount Rochfort (Nelson).

Dracophyllum ramosum Br. & Gris. (Fig. 17.)

Dracophyllum ramosum Brongn. & Gris. *Ann. Sci. Nat. Bot.* 2, 156, 1864.

Characters.—A noticeable feature in the life form of this species is that 3-6 branches may arise from nearly the same point This is also a characteristic of *D. strictum.* The leaves are straight, moderately broad, with expanded sheaths; length 85-125 mm., width 11 mm. They decrease in size towards the inflorescence. The panicle is 10-20 cm. in length, with the flowers on short branches covered with white pubescence. There are 7-8 flowers on the lower branches. The sepals are as long as the corolla-tube, ribbed, acute, ciliate. Corolla-lobes short. This species has already been compared with *D. strictum.* It might also be compared with *D. secundum,* which it resembles in the acute sepals reaching to the top of the corolla-tube and in the long leaves and panicles; but in *D. ramosum* the leaves are much broader and the flowers of the panicle denser than in *D. secundum.*

Distribution.—New Caledonia. (Specimens examined)—Baie du Sud, inland from Baie des Piroques, Mountains near Gatope. (Recorded)—M'bee (type locality), Ngoye.

Dracophyllum secundum (Poir) R. Br.

Epacris secunda Poir. *Encycl. Suppl.* 2, p. 556, 1810-16. *Prionotes secunda* Spreng, *Syst. Veg.* 1, p. 631, 1822. *Dracophyllum secundum* R. Br. *Prodr. Fl. Nov. Holl.* 556, 1810. Benth *Fl. Austr.* 4, 262, 1869.

Characters.—The leaves are long and comparatively narrow, 140 × 7, 80 × 6 mm. The panicle is long with large flowers on rather long slender pedicels, there being four on the lower branches.

Sepals long, acuminate, as long as the corolla-tube. Corolla-lobes rather long, spreading.

I associate this species with *D. Vieillardii* rather than with *D. ramosum* on account of the characters of the panicle, especially the few flowers to each branch. The sepals and corolla also agree except that in *D. secundum* the corolla-tube is glabrous. The leaves of *D. secundum* are longer than they are in *D. Vieillardii.*

Distribution.—Eastern New South Wales. (Specimens examined)—Oatley, Blue Mountains (Sieber's specimen). (Recorded)—Illawarra.

Dracophyllum Vieillardii Lenorm.

Dracophyllum Vieillardii Lenorm. ex Guill. *Ann. Mus. Col. Marseilles* (2) 9, 181, 1911 (name only).

Characters.—The leaves are stiff, straight, tapering evenly to a blunt point. They are rather short, and decrease in size towards the inflorescence. Length 68 mm. (including sheath 13 mm.) width 6 mm. The panicle is long and slender, 90 mm. long, each branch bearing three flowers. Sepals equalling the corolla-tube, ribbed, ciliate on the margins. Corolla-tube 6 mm. ciliate on the upper part below the lobes which are broad and obtuse. Anthers well included.

D. Vieillardii is closely allied to *D. amabile* agreeing with it generally in the characters of the leaves and panicles, but in *D. Vieillardii* there are only three flowers to each branch of the panicle instead of 5 as in *D. amabile* and the corolla-tube is much longer. The stamens also do not reach so far up the corolla-tube as in *D. amabile.*

Distribution.—New Caledonia. (Specimens examined)—Dombea (Coll. Vieillard).

Dracophyllum amabile Br. & Gris. (Fig. 18.)

Dracophyllum amabile Brongn. & Gris. *Ann. Sci. Nat. Bot.* 2, 157, 1864 (Kanala.).

Characters.—A slender species with rather small leaves and longer slender panicles. Leaves tapering to a hard blunt point, widening gradually below into the sheath, margins smooth. Length 80 mm., breadth 6 mm. Panicle 120 mm. long, rhachis pubescent; generally five flowers on the lower branches. Flowers small, sepals ovate, acute, ciliate, 3 mm. long; corolla-tube 4 mm. long; stamens included. *D. amabile* differs from *D. Vieillardi* in the smaller flowers with proportionately shorter sepals and in the lower panicle branches bearing 5 flowers.

Distribution.—New Caledonia, in arid scrub country. (Specimens examined)—Mountains de Kanala.

Dracophyllum gracile Br. & Gris.

Dracophyllum gracile Brongr. & Gris. *Ann. Sci. Nat. Bot.* 2, 156, 1864 (not of R. Br.).

The name *gracile* is retained for this species for precisely the same reason that *squarrosum* is reinstated for the New Zealand species

named *Sinclairii* by Cheeseman. The Western Australian species described under the name *Dracophyllum gracile* in Bentham's *Flora Australiensis* was originally described by Poiret as *Epacris gracilis* and later transferred to *Sphenotoma,* in which genus it is now universally placed.

Characters.—The subacicular leaves, and panicles equal to or slightly longer than them, and with the rhachides and sepals ciliate, serve to distinguish this species from its allies. The leaves are almost acicular and are disposed in dense clusters at the tips of the branches; length 50 mm. (including the sheath 7 mm.), width of sheath 4 mm., of lamina 1.5 mm. The leaf is brown, convex below, slightly hollowed above, margins of lamina roughened, of sheath ciliate. Panicles short, only slightly projecting beyond the leaves, rhachis and pedicels pubescent. Flowers disposed in threes, twos, or singly. Sepals ovate, acute, red, ribbed, with ciliate margins. Stamens included in the corolla-tube.

In its narrow leaves and few-flowered short panicles *D. gracile* comes nearest to *D. Thiebautii.* It differs in the leaves being subacicular, the panicle about equalling the leaves in length, and in being pubescent.

Distribution.—New Caledonia, in scrub land. (Specimens examined) Hoay. (Recorded)—Arnaud (type locality), Ngoye.

Dracophyllum Thiebautii Br. & Gris.

Dracophyllum Thiebautii Brongn. & Gris. *Ann. Sci. Nat. Bot.* 3, 238, 1865 ((Arama).

Characters.—This species is distinguished by its long narrow leaves, and short glabrous panicles with few flowers. It is a shrub 1 m. tall. The leaves are very narrow, and end in solid sharp points, margin indistinctly serrated, sheath expanded, length 120 mm. (including sheath 9 mm.) width of lamina 4 mm. Panicle not nearly reaching to the end of the leaves; rhachis glabrous, flowers in fascicles of threes, or twos, or solitary. Sepals ovate, acuminate, 5 mm. long. I have seen no flowers, but Brongniart and Gris describe the stamens as exserted. *D. Thiebautii* is to be compared only with *D. gracile,* but the wider leaves and relatively short panicle at once distinguish it.

Distribution.—New Caledonia. (Specimen examined)—Riodes Piroques, among rocks in the river (C. T. White). (Recorded)—Arama (type locality).

Group of *D. Milligani.*

Trees. Leaves long and broad. Panicle large, compound. Sepals acute, corolla long and narrow, anthers slightly exserted.

This group is placed near the New Zealand group of *D. latifolium* because of its compound panicles, but it differs in its long narrow corolla-tube with the anthers not so far exserted. The species may be distinguished from one another by well-marked characters in the leaves and inflorescence, the shape of the bracts being especially distinctive. Geographically the four species included in the group are widely separated, being found in Tasmania, Queensland, New Caledonia, and Lord Howe Island respectively.

Dracophyllum Sayeri F. V. Muell. (Fig. 19.)

Dracophyllum Sayeri F. V. Muell. *Austr. Journ. Pharm.* 1887. Bailey, *Queensland Fl.* 3, 942, 1900.

Characters.—A tree 6-8 m. tall, the "branches intricately spreading, forming an almost impenetrable mass" (Bailey). Leaves, in clusters at the tips of the branches, tapering, drawn out into a long acuminate point. Length 38 cm., width 18 mm. Panicles shorter than the leaves, the branches bearing about 20 flowers. Bracts narrowed at both ends, length 85 mm.; the distal ones with a broad base and a tapering lamina. Sepals acute, much shorter than the calyx. Corolla with long blunt-pointed lobes. Anthers exserted. Stigma club-shaped. Bailey states that the corolla may be either white with rose-coloured lobes, or entirely white.

D. Sayeri differs from its allies in the shape of the bracts. It perhaps comes nearest to *D. dracaenoides* resembling this species in the panicle about equalling the leaves, the short sepals and club-shaped stigma.

Distribution.—Bellenden Ker Range, Queensland.

Dracophyllum dracaenoides Schltr.

Dracophyllum dracaenoides Schlechter, *Engl. Bot. Jahr.* 39, 220, 1906.

Characters.—This is the only species of *Dracophyllum* that I have not examined. Schlechter gives a good figure from which it is safe to say that it comes very close to *D. Sayeri*, with which it agrees in the panicle about equalling the leaves, the short sepals and club-shaped style. But it differs in being but a shrub and in the leaves being serrulate. According to Schlechter *D. dracaenoides* is a shrub 2 m. tall, the leaves are 15-20 cm. long, and 7-10 mm. wide with serrulate margins. The sepals are 2 mm. and the corolla 4 mm. long; the stamens are exserted and the style club-shaped.

Distribution.—New Caledonia, mountains near Ou Hinna.

Dracophyllum Milligani Hook. f. (Fig. 20.)

Dracophyllum Milligani Hook. f. *Ic. Pl.* pl. 845, 1852. Bentham *Fl. Austr.* 4, 262, 1869. Rodway *Tas. Fl.* 126, 1903.

Characters.—According to Rodway *D. Milligani* is an unbranched shrub reaching a height of 8 feet (2.5 m.) with leaves 2 feet (60 cm.) in length. The only leaves I have seen have a broad sheathing base, from which they gradually narrow to a thick lamina ending in a long point which curls in dried specimens. The margins are finely crenulate. Length 20 cm., width above sheath 10 mm. Panicle long (1½ feet (46 cm.) according to Bentham), the branches bearing numerous flowers, rhachis ribbed, sparingly pubescent. Bracts with broad sheathing-bases suddenly contracted into long attenuated points which curl at the tips, length up to 32 cm., width 6 mm. Sepals ovate, acute, equalling in length the corolla-tube; margins ciliate. Anthers exserted. Stigma capitate.

D. Milligani seems to approach *D. Fitzgeraldi* more closely than any other. Noticeable differences are the longer drawn-out tips to the leaves and bracts, the longer panicles, and the longer sepals in proportion to the corolla-tube.

Distribution.—Tasmania. (Specimens examined)—Mount Zeehan. (Recorded)—Mount Sorrell, Mount La Perouse, Mount Read, Adamson Peak.

Dracophyllum Fitzgeraldi Moore & F. V. Muell. (Fig. 21.)

Dracophyllum Fitzgeraldi Moore & F. V. Muell. *Fragm. Phytogr. Austr.* 7, 27, 1869. Oliver, *Trans. N.Z. Inst.* 49, 146, 1917.

Characters.—A large spreading tree with a trunk 50 cm. in diameter, covered with rough reddish-brown bark. Leaves gradually tapering and drawn out into a long acuminate tip, curling in dried specimens; gradually widening below to the sheath. Length 35 cm., width above the sheath 25 mm.; width of sheath 40 mm. Panicle shorter than the leaves; the branches with broad bases, much branched and supporting numerous flowers. Sepals shorter than the tube of the corolla, ovate, acute, with ciliate margins. Anthers exserted. Stigma capitate. Bracts broadly ovate suddenly narrowed into short acuminate tip.

D. Fitzgeraldi resembles *D. Milligani* in many respects but is larger and has shorter panicles and bracts. It might be compared with *D. dracaenoides,* but the panicle is more branched, the stigma capitate instead of club-shaped, and the sepals much longer.

Distribution.—Lord Howe Island.

Group of *D. latifolium.*

Trees. Leaves long and broad. Panicle compound. Sepals obtuse short; corolla short, stamens exserted.

This group is allied to that of *D. Milligani,* but the short sepals, short wide corolla, and far-exserted stamens separate it as a group which has advanced further from the primitive group of *D. minimum.* The four species included are closely allied. Two have slender panicles and leaves little expanded below—*D. latifolium, D. Matthewsii*; the other two have stout panicles and leaves with broad sheaths—*D. recurvatum, D. Traversii.* All the species are confined to New Zealand, one being found in the South Island (*D. Traversii*), and the three others in the North Island.

Dracophyllum latifolium A. Cunn.

Dracophyllum latifolium A. Cunn. *Ann. Nat. Hist.* 2, 48, 1838. Cheeseman *Man. N.Z. Fl.* 701, 1925; *Ill. N.Z. Fl.* part text only, 1914.

Characters.—A tree 5-7 m. tall with rough bark. Leaves long, wide, gradually tapering, slightly expanded below, length to 535 mm., width 23 mm., more commonly about 400 mm. long. Panicle slender, erect, branches arising at an acute angle. Flowers reddish. Capsules 2.5 mm. across on pedicels 2-2.5 mm. long.

The characters used in this description are those which are useful in contrasting it with *D. Matthewsii* from which it differs in its larger leaves, larger erect panicle, and reddish flowers. The flowering season too is later, being from December to January.

Distribution.—North Island from Waikaremoana northwards. (Specimens examined) Fairburn, Tutamoe, Great Omaha, Te Whaiti, Titirangi, Waikaremoana, Mount Te Aroha, Kaihu Valley.

Dracophyllum Matthewsii Carse.

Dracophyllum latifolium var. *Matthewsii* Carse, *Trans. N.Z. Inst.* 48, 238, 1916.

D. Matthewsii Carse, *l.c.* 56, 86, 1926.

D. latifolium Cheesem. (not A. Cunn.) *Ill. N.Z. Fl.* pl. 129, 1914.

Characters.—A shrub or small tree, 3-5 m. tall. Leaves short, thin, acuminate, slightly widening below, length 200-230 mm., width 17-20 mm. Panicle slender, drooping, branches arising at an acute angle. Flowers purplish, red to black. Capsules small, 2 mm. across, on pedicels 1 5 mm. long. The small size, small decurved panicles, purple flowers, and small fruit distinguish this species from *D. latifolium.* It flowers during September and October.

Distribution.—North Auckland. (Specimens examined)—Pukepoto, Maungatanipha, and Peria (Mangonui County). Little Barrier Island, Whangarei, Thames, Taumatamahoe Range.

Dracophyllum Traversii Hook. f. (Fig. 22.)

Dracophyllum Traversii Hook. f. *Handb. N.Z. Fl.* 736, 1867. Cheeseman, *Man. N.Z. Fl.* 702, 1925.

Characters.—A tree 10-13 m. tall. Bark smooth, brown. Leaves long, with a broad base suddenly narrowing to the lamina which tapers gradually and is drawn out into a long narrow point. Length up to 62 cm., width above the sheath 28 mm. Panicle stout. Flowers large. Capsules large 3 mm. across on short pedicels.

D. Traversii is closely allied to the North Island *D. recurvatum.* It may be distinguished by the leaves having fine, long, drawn-out tips, and the larger flowers and capsules. The branches of the panicle usually arise at a more acute angle.

Distribution.—Western side of the South Island from Nelson to South Westland. (Specimens examined)—Mount Arthur Plateau, Rangi Taipo (Teremakau River), Arthurs Pass, Paringa River (S. Westland). (Recorded)—Upper Takaka, Paparoa Mountains, Paparoa Range, Mount Glasgow, Mount Greenland, Franz Josef Glacier, Copland Pass, Jackson Bay, Haast River.

Dracophyllum recurvatum Col. (Fig. 23.)

Dracophyllum recurvatum Col. *Trans. N.Z. Inst.* 21, 93, 1889 (Lake Waikaremoana).

This species was first described by Colenso, who clearly records its distinctive characters. Colenso's name has, however, been gener-

ally regarded as a synonym of *D. latifolium,* and specimens in herbaria have been included with *D. latifolium,* though Cheeseman in the first edition of the *Manual* notes that a state of *D. latifolium* found on high peaks in the Auckland district resembles *D. Traversii.* In 1926 I found this species high up on Mount Hikurangi and noted its distinctness from *D. latifolium* by its stout panicles. Subsequently I recognized Colenso's *D. recurvatum* as being the same species.

Characters.—A slender tree 10 m. tall, with smooth brown or grey bark. Leaves long, tapering, with a broad base gradually narrowing to the lamina, length 50-62 cm., width above sheath 26-30 mm. Panicle stout. Capsules small, 2 mm. across, on short pedicels or sessile. Distinguished from *D. Traversii* by the more uniformly tapering leaves, and the smaller capsules (and presumably smaller flowers, which I have not seen). In the specimen from Mount Hikurangi the branches of the panicle arise at almost a right angle.

Distribution.—North Island from Mount Hikurangi and Lake Waikaremoana northwards. (Specimens examined)—Little Barrier Island, Thames Goldfields, Mount Te Aroha, Mount Hikurangi. (Recorded)—Lake Waikaremoana (type locality).

Group of *D. verticillatum.*

A shrub with long broad leaves and very long spike-like panicle bearing the flowers in clusters at close intervals. Corolla short; anthers exserted. This group differs from the other species groups of the subgenus *Eudrocophyllum* in the arrangement of the flowers on the rachis of the panicle coupled with the short open corolla. Each flower cluster occupies a third of the circumference of the rhachis and consists of 10-12, or fewer by fusion, small branches each branching again and bearing several flowers. This arrangement allies the group to the group of *D. secundum,* but the structure of the flower separates it as a more advanced group. The only species is the type of the genus *Dracophyllum* and comes from New Caledonia.

Dracophyllum verticillatum Lab. (Fig 24.)

Dracophyllum verticillatum Labill, *Voy. La. Per.* 2, 211, pl. 40, 1800.

Characters.—"A very beautiful shrub, with the flowering spike about 5 feet high. Flowers white, buds tinged with pink. Slightly honey-scented" (C. T. White, Queensland Herbarium). Leaves long, acuminate, drawn out into a long point; margins slightly serrated; base gradually expanded into a broad sheath; length 46 cm. Panicle 70 cm. Sepals broad, obtuse; corolla-tube broad, short, lobes recurved; anthers exserted; stigma club-shaped. Capsule pentagonal, hollowed above.

Distribution.—New Caledonia, "Open exposed hillsides among scrubby vegetation" (C. T. White). (Specimens examined)—Mount Mou Mou. (Recorded)—Balade, Pic Malaoni.

Subgenus *Cordophyllum*, n. subg.

Rachis robustus, erectus; floribus dense confertis verticillatis; penduneulis 1—floris bracteis imbricatis; tubo corollae augusto.

Flowers in dense fascioles encircling at intervals a stout rachis, each flower on a separate peduncle clothed with bracts. Corolla narrow, anthers included. Type species *Dracophyllum involucratum* Br. & Gris.

The peculiar features about the species for which this subgenus is founded are the primitive flowers on a specialized inflorescence. Each flowering peduncle might be compared with a separate branch of such a species as *D. minimum* but the spike-like inflorescence should be compared with that of *D. verticillatum*. Hence I propose for it a group equivalent to *Oreothamnus* and *Eudrocophyllum*. The single species, *D. incolucratum*, comes from New Caledonia.

Dracophyllum involucratum Br. & Gris. (Fig. 25.)

Dracophyllum involucratum Brongn. & Gris. *Ann. Sci. Nat. Bot.* 2, 157, 1864 (Yate).

Characters.—Leaves broad, gradually tapering from the base and extending into a long acuminate point; margins with remote minute teeth; length 30 cm., width above sheath 26 mm. Rachis 40 cm., ribbed, densely tomentose. Flowers in dense clusters surrounding the rachis at regular intervals. Peduncles 10 mm. long, clothed with small imbricating ovate, acute ciliate bracts, and bearing a single terminal flower. Stamens included in the throat of the corolla; stigma club-shaped.

Distribution.—New Caledonia. The specimen which I examined was loaned by the Government Botanist of Queensland. (Locality not stated.) The type comes from mountains near Yate.

Vegetation of the Upper Bealey River Basin, with a List of the Species.

By ROBERT M. LAING, B.Sc., F.N.Z.Inst.,

AND

W. R. B. OLIVER, M.Sc., F.N.Z.Inst., Director, Dominion Museum, Wellington, N.Z.

[*Read before the Philosophical Institute of Canterbury, April 4th, 1928; received by Editor, 4th October, 1928; issued separately, 25th March, 1929.*]

THIS paper proposes to give the names of the flowering plants and ferns collected in the Basin of the Bealey between the mouth of the Mingha and the Western Divide. It is strange that hitherto no comprehensive list of the plants of this area has been attempted. Many botanists have visited the district, and no portion of the Southern Alps is better known to visitors and tourists, many thousands of whom annually cross Arthurs Pass. The authors therefore desire to provide such with a reliable list of the species likely to be met with, and to furnish a basis for the further study of the florula of the district. As much of the area is practically inaccessible the list cannot be complete, but it probably contains about ninety per cent. of the species. A few records of plants not seen by the authors from the writings of earlier investigators have been included.

CHARACTERISTICS OF THE FLORA.

The Upper Mingha and many of the higher valleys and ridges have not been visited by us. The region is indeed inexhaustible, and though the vegetation at similar elevations is fairly uniform, there are doubtless a good many rare and local species that have not yet been collected. For the present also, the more critical forms, some hybrids and novelties, are omitted. Some of the genera, particularly *Celmisia, Olearia, Coriaria, Acaena,* and possibly *Epilobium,* swarm with hybrids.

A collection has been made including nearly all the species listed, and may be viewed at Arthurs Pass by those interested. It is hoped that thus some, who have only had a casual knowledge of the subject, may be roused to take an interest in the scientific side of it. Unfortunately at present the roadsides and neighbouring hills and streams are rapidly being despoiled of their characteristic vegetation by tourists who gather armfuls of the blossoms of *Metrosideros, Elytranthe, Ranunculus Lyalli, Celmisia, Senecio* and of other genera, in many cases only to leave them to die by the roadside. If this depredation can be reduced by a fuller understanding of the beauty and uniqueness of our native flora, there may be some hope of preventing the harm that is being done at present to the plants on the sides of the main road over the pass and on the most travelled tracks.

Some remarks are here offered as to the general characteristics of the vegetation of the district. The florula is comparatively limited in species, no doubt for the following main reasons:—

(1) High evaporation rate.
(2) Lack of soil.
(3) Low winter temperature.
(4) Frequent heavy gales.
(5) Prejudicial effect of beech forest on the germination of seedlings.

A few remarks will be offered under each head:

(1) *High evaporation rate.*—In spite of the huge rainfall, averaging about 180 inches in the year, the atmosphere is a dry one, and the plants are those of a comparatively dry area. This somewhat paradoxical fact is due to the effect of the mountain range on the moisture contained in the prevailing northwest wind. As the wind descends the Southern Alps it becomes warmer, and rises higher and higher in temperature above the dew point, so that finally the rate of evaporation becomes extremely high. Unfortunately no records are available to illustrate this, but there can be no doubt that in spite of the high precipitation the atmosphere is usually dry. The rainfall as recorded at the Arthurs Pass Railway Station from 1924-1927 is as follows: 1924, 160 in.; 1925, 201 in.; 1926, 205 in.; 1927, 171 in. As a rule the rain, which comes mostly from the northwest, falls heavily and disappears quickly. On one occasion 17 in. fell in twenty-four hours, but the very heavy rainfall does not preclude occasional periods of drought. Thus in January 1928 the rainfall was considerably under an inch, and for the first three months of 1928 it was only 14 in. During January the vegetation was in many places parched or even killed, and the rain of March and February fell in short periods of time. During the whole period the streams were unprecedentedly low. On the other hand, in the first three months of 1927, 58 in. of rain fell. An illustration of abnormal evaporation may be given. Mr. S. Page informs us that he has seen light rain falling from a low cloud at Arthurs Pass to within ten or twelve feet of the ground and then evaporating. This unusual phenomenon was doubtless exceptional, but it, and the slow rusting of iron that is apparent, obviously could only occur with an exceptionally high rate of evaporation. The complete absence of miro, matai, rimu, and kamahi, and almost complete absence of rata, though all of these are abundant in the Otira Valley, are no doubt in part due to this cause. Similarly the larger and softer-leaved coprosmas and olearias are chiefly confined to the western side of the range, or the higher valleys on the eastern side; e.g. *Olearia Colensoi* is almost entirely a plant of the west, *Coprosma lucida* is abundant in the Otira Valley, but so far only one plant has been found on the eastern side. Generally speaking the forest and sub-alpine scrub of the eastern side consists of small-leaved plants.

(2) *Lack of Soil.*—As the hillsides and valleys are up to about 4,000 ft. or 4,500 ft. everywhere covered with loose shingle, in places overlain by two or three inches of soil, the rain rapidly sinks through

below the surface-level, and much of it passes away in under-ground streams. The lack of soil tends to limitation of species, and the limitation of species tends in turn to lack of soil. It is only in flat places, therefore, which soon turn into bog, that the ground is always damp, though bog may also be found on hillsides near stream courses, near under-ground streams, or where there is no surface shingle. The result is that the vegetation of the hillsides is generally xerophytic. Such plants of dry districts as *Exocarpus Bidwillii, Hebe Lycopodioides, Discaria toumatou,* are abundant in certain situations within the valley. Here and there on the river-valleys there is a comparatively deep rich soil, no doubt formed in succession from some old sphagnum bog, but the steepness of the hills and the presence of boulders, angular rocks, and shingle slopes apparently prevent the accumulation of humus elsewhere. Another contributing factor is the almost complete absence of dust from the atmosphere, so that even the river-bed raoulias do not develop the thick cushions that they do in the lower plains, where the abundant dust blown before the northwest wind-storms tends to build them up into ever higher and higher cushions. *Raoulia australis* and *R. tenuicaulis* here lie flat on the ground, though *R. Haastii* forms cushions up to 3 or 4 inches in thickness. Where the river-bed is not subject to floods, under the thin layer of humus may be found four or six inches of clay. Only in the older bogs or in soil consolidated from these bogs is there any depth of humus.

(3) *Low winter temperatures.*—Another factor limiting the number of species present is the extreme winter cold, due in part to altitude, in part to the fact that there are here narrow valleys shut in on all sides by mountain ridges, and in part to the proximity of high snow-covered mountain peaks. The area dealt with lies roughly between 2,200ft. altitude and 6,000 ft., the limit of vegetation, though several plants have been found at 7,000 ft. on Mount Rolleston. This, which is the dominating peak of the district, is roughly 7,400 ft. in height. Unfortunately again no figures are available for winter temperatures, though a minimum thermometer has now been placed in the district; but there can be no doubt that in winter frosts the thermometer falls to zero Fahrenheit. In the winter of 1925 snow fell to the depth of 2 ft. 6 ins. in the settlement (2,400 ft. elevation), and of 3 to 5 ft. in the col of the pass (3,000 ft. elevation). This was undoubtedly exceptional, for as a result a snow-field was formed in the head of the Bealey river, which as it slipped downwards bore away the *Nothofagus* forest, trees being destroyed which had been growing from twenty-five to forty years.

(4) *Wind.*—For about nine months in the year the area is subject to strong, sometimes violent, gales from the northwest. The months of May, June and July, are usually fairly calm. The only other wind that is at all prevalent is the southwester which alternates with the northwest; but probably there is only one day southwest for every three days of northwest wind. Of course the direction of the winds is largely controlled by the direction of the valleys, so that in Bealey valley the southwester of the plains is approximately southeast in direction. Though there is little evidence in storm-

twisted or brush-back trees, of the general direction of the wind, it is undoubtedly one of the factors in limiting forest growth; and the absence of forest from the sides of the hills at the top of the pass is evidently in part due to the strength of the winds there. Usually the forest line lies between 4,000 and 4,500 ft.; but here it is only 3,000 ft. The winds must of course immensely increase the rate of evaporation and so add to the dryness of atmosphere.

(5) *The effect of the* Nothofagus *forest on undergrowth.*—It is well known that the *Nothofagus* forests are freer from undergrowth than any other type of New Zealand forest. In the lower Mingha valley the forest is nearly pure *Nothofagus cliffortioides.* In the Bealey proper there is a much greater intermixture of species. Where the dry hard beech-leaves fall and accumulate and there is a heavy canopy of beech branches overhead, little undergrowth apparently can exist. The beech-leaves only slowly turn into humus, and no good seed-bed is formed. Though not so prejudicial to growth as pine needles, they seem to have a similar effect. Owing to the ravages of man in the Bealey valley, and in more recent years to those of a bud-burrowing larva, the beech forest has suffered much, resulting in a greater and greater development of undergrowth. At present indeed insect larvae are doing much harm to many different species. those especially attacked are *Nothofagus cliffortioides, Phyllocladus alpinus,* species of *Coriaria* and *Ranunculus Lyallii. Hoheria glabrata* is also subject to pests, but comes up in large quantities where the beech has been cut down. It is not intended to discuss the problems of succession here, but merely to indicate that the forest is by no means stable. Obviously under conditions such as those described, the ordinary coastal vegetation of such an area as Banks Peninsula cannot exist, and consequently we find that the forest trees and shrubs of the coastal area are for the most part absent here. Thus tree-ferns are unrepresented except by the low-growing *Alsophila Colensoi,* and only three species of filmy fern have so far been discovered, though many species are abundant at Otira. *Hedycarya, Carpodetus, Pittosporum eugenioides,* species of *Sophora, Pennantia corymbosa, Melicytus ramiflorus, Hoheria angustifolia, Plagianthus betulinus, Schefflera digitata, Nothopanax arboreum,* and other common trees and shrubs of the coastal area are missing here. Indeed the only conspicuous forest trees of Banks Peninsula to be found in the Bealey watershed are *Griselinia littoralis, Aristotelia serrata* (chiefly in sheltered gullies), and *Fuchsia excorticata.* The two latter no doubt owe their presence to the fact that one is partly and the other totally deciduous in winter. Of course these differences in the lowland and sub-alpine forests are known to all observers, but we think it well to call special attention to them in order to emphasize the existence of the conditions that we are dealing with. Mention should also be made of the almost total absence of lianes and phanerogamic epiphytes; *Clematis indivisa* for example occurs in the Otira Gorge but not in the upper Bealey Valley; *Muehlenbeckia australis* is also absent, and the only lianes or scramblers common are two species of *Rubus.* There are also so far as noted no flowering epiphytes here, the forest in consequence having none of that sub-tropical appearance so frequently noted in the New Zealand

bush. The absence of lianes and epiphytes, which are mostly plants of warmer regions, is doubtless due to the low winter temperature. However, the total number of species present is apparently somewhat higher than in the Mt. Cook region, where the flora has been listed by Professor A. Wall. There the higher mountains and the absence of a low pass probably account for the smaller number of species.

One other point already referred to in these introductory notes should be further emphasized, and that is the remarkable contrast in the vegetation of the eastern and western sides of the range; of this we can give no complete explanation, nor do we propose to consider it at length here, but the least observant cannot fail to notice the comparative richness of the Otira plant life compared with that in Arthurs Pass. The township of Otira is some 1,250 ft. lower than the Arthurs Pass settlement, very much warmer, has doubtless a much moister atmosphere and a richer soil, and to these conditions much of the greater wealth of species must be due; but further explanations are probably needed to account for the absence of certain species from the colder area. These, however, can only be dealt with when the vegetation of the western side of the range is more fully known.

THE PLANT FORMATIONS.

The vegetative covering of the Bealey Valley basin includes a fairly representative sample of the sub-alpine and alpine plant-formations of New Zealand. The series extends from mountain beech-forest through bog, scrub and tussock to fell-field at the upper limit of vegetation. In the list of species appended to this paper the main plant-formations in which each is found is given in a general way. What these formations consist of will now briefly be indicated.

Forest.—Forest covers the mountain sides up to an altitude of about 4,500 ft. except in the pass itself where it is quite absent. Its limits correspond precisely to the area exposed to the full force of the northwest wind. The dominant tree, and for the most part the only tall tree in the forest, is the mountain beech, *Nothofagus cliffortioides.* Rarely is a tree of the pahautea, *Libocedrus Bidwillii,* met with. Other trees present, such as *Nothopanax simplex* and *Griselinia littoralis* belong to a lower tier of foliage. The undergrowth, consisting of shrubs with a few ferns and herbaceous plants, is not dense except in places where a valley bottom somewhat permits the soil to retain its water.

A subassociation of the forest is that formed where *Dacrydium biforme* mixes with the stunted trees of the beech. This occurs in situations unfavourable to tree-growth, namely in boggy ground and on exposed ridges.

Scrub.—Three distinct scrub-formations are present in the Bealey Basin. On the river bed is *Discaria* scrub, but only a fragment is left, and of this the original species are almost all exterminated except the *Discaria* and a *Coprosma.* In the forest-belt on exposed ridges is a low scrub in which the principal members are *Leptospermum scoparium* and *Exocarpus Bidwillii.* Above the forest-belt is sub-alpine scrub, in which species of *Dracophyllum, Phyllocladus,* and

various composite shrubs play a conspicuous part. Several associations can be defined.

Tussock.—In situations inimical to shrub-growth either on account of exposure, or of deficient drainage, tussock-formation occurs. *Danthonia Raoulii* is dominant over most of the area, but along the higher levels *D. crassiuscula* is the principal species.

Bog occurs on all fairly level stretches of land either in the forest zone or above it. Its dominant life-forms are cushion-plants, of which *Donatia novae-zealandiae* and *Gaimardia setacea* are perhaps the most conspicuous.

Cushion-plant associations other than bog include the shingle-bed of the Bealey River, in which species of *Raoulia* are most conspicuous, and some open associations above the scrub-line. These alpine cushion-plant associations are generally situated on seepage-slopes, and hence the habitat differs from that of bogs in being well drained. *Phyllachne clavigera* and *Anisotome imbricata* are the dominant species.

Meadow.—The alpine meadows are among the most wonderful sights to be seen on the mountains. They border streams at altitudes of from 3,000 to 5,000 ft. The dominant plants are showy species of *Senecio* (*S. Lyallii* and *S. scorzoneroides*) and *Ranunculus Lyallii.*

Fell-field.—Under this term is included the open rocky portions of the mountain from about 5,000 ft. to the upper limit of vegetation. The plants occur in clumps or singly in crevices among the rocks. They include cushion-plants like *Hectorella* and *Pygmea,* herbs like *Senecio scorzoneroides,* and shingle-plants like *Hebe Haastii.*

Shingle-slips are common on the mountains but only a few true shingle-slip plants are present. *Haastia Sinclairii* is the most common shingle plant. These slips, however, are not so much consolidated as in the mountains to the eastward, and are composed of larger and perhaps more angular fragments.

Reed swamp is characterized by the presence of species of *Carex, Heleocharis* and *Juncus.* It occurs on the Bealey river bed where *Heleocharis acuta* is common, and within the forest-zone where *Carex ternaria* is the most prominent species.

Water formations occur by streams in the main river-bed and on the mountains. Two formations at least may be distinguished, one in which *Potamogeton* and *Myriophyllum* occur, and another with *Montia* and *Epilobium macropus* as the most conspicuous members.

List of Species of Pteridophytes and Spermophytes.

* Species not observed by the authors.

Lycopodiaceae.

Lycopodium Selago Linn.	Scrub.
L. novae-zealandicum Col.	Forest.

We have given this form the rank of species as it appears to us to be as much entitled to it as is *L. varium.* It is possible that the three forms—*Billardieri, varium,* and *novae-zealandicum* are but habitat forms of one polymorphic species. In any case we consider them each of equal status.

L. fastigiatum R. Br.	Bog. tussock.
L. scariosum Forst.	Forest.

HYMENOPHYLLACEAE.

Hymenophyllum flabellatum Lab.	Forest.
H. villosum Col.	Forest.
H. multifidum (Forst.) Sw.	Forest, scrub.

GLEICHENIACEAE.

Gleichenia dicarpa R. Br. var. *alpina* (R. Br.) Hook. f.	Bog.
G. Cunninghamii Heward.	Forest on ridge.

OSMUNDACEAE.

Leptopteris superba (Col) Presl.	Forest.

SCHIZAEACEAE.

Schizaea fistulosa Lab.	Bog.

CYATHEACEAE.

Alsophila Colensoi Hook. f.	Forest.

POLYPODIACEAE.

Cystopteris fragilis Bernh.	Forest.
Polystichum vestitum (Sw) Presl.	Forest, scrub.
P. cystotegium (Hook) J. B. Armstr.	Shingle slips.
Asplenium Richardi Hook. f.	Forest.
A. trichomanes Linn.	Forest (Halpins Creek).
Blechnum (*Lomaria*) *procerum* (Forst.)	Forest.
B. (*L*) *fluviatile* (R. Br.) Salom.	Forest.
B. (*L*) *penna-marina* (Poir.) Kuhn.	Forest.
B. (L) *lanceolatum* (Spreng.) Sturm.	By side of creek in forest.
B. (*L*) *vulcanicum* (Blume) Kuhn.	Forest.
Hypolepis millefolium Hook. f.	Forest.
Histiopteris incisa (Thunb.) J. Sm.	In second-growth forest and scrub.
Pteridium esculentum (Forst.) Ckne.	Forest on ridge.
Paesia scaberula (A. Rich) Kuhn.	Forest on ridge.
Polypodium Billardieri (Willd.) C. Chr.	Forest.
P. pumilum (Armstr.) Ckne.	Cushion plant formation.

PINACEAE.

Libocedrus Bidwillii Hook. f.	Forest.

PODOCARPACEAE.

Podocarpus Hallii Kirk.	Forest.
P. nivalis Hook.	Forest, scrub, tussock.
P. Hallii × *nivalis*	Forest.
Dacrydium biforme (Hook) Pilg.	Bog and dry forests.
D. laxifolium Hook. f.	Bog, scrub.
Phyllocladus alpinus Hook. f.	Scrub.

NAIADACEAE.

Potamogeton Cheesmanii Benn.	Water in river-bed.

GRAMINEAE.

Hierochloe redolens R. Br.	Forest, scrub.
Ehrharta Colensoi Hook. f.	Shingle slips, tussock.
Deyeuxia Forsteri (Roem et Schult). Kunth.	Forest.
Agrostis subulata Hook. f.	Fellfield, Senecio meadow.
A. Dyeri Petrie.	Tussock.
**Deschampsia Chapmani* Petrie.	(Recorded by Cheeseman).
Trisetum Youngii Hook. f.	Tussock.
Danthonia Raoulii Steud.	Tussock.
D. flavescens. Hook. f.	Forest, tussock, swamp.
D. crassiuscula Kirk.	Tussock.
D. oreophila Petrie.	Forest, tussock, fellfield.
D. pilosa R. Br.	Tussock.
D. Cunninghamii Hook. f.	Forest edge.
Poa Lindsayi Hook. f.	River-bed.
P. novae-zealandiae Hack.	Forest, fellfield. Mt. Rolleston, 7,000 ft. (Miss E. Washbourn).
P. Colensoi Hook. f. var. *breviligulata* Petrie.	Scrub, tussock, fellfield.
P. Cockayneana Petrie.	Scrub.
Festuca novae-zealandiae (Hack) Ckne.	Tussock.
**Agropyrum aristatum* (Petrie) Cheesm.	(Recorded by Cheeseman).

CYPERACEAE.

Heleocharis acuta R. Br.	Swamp in river-bed.
Scirpus cernuus Vahl.	Ranunculus meadow.
Carpha alpina R. Br.	Bog.
Schoenus pauciflorus Hook. f.	Forest, bog, Senecio meadow, tussock.
Oroeobolus strictus Berggr.	Bog.
O. pumilio R. Br.	Bog, tussock.
O. pectinatus Hook. f.	Bog.
Uncinia compacta R. Br.	River-bed.
U. caespitosa Boott.	Forest, scrub.
U. filiformis Boott.	Forest.
U. riparia R. Br.	Forest.
U uncinata (L) Kukenth.	Forest.

We have accepted *uncinata* as the correct specific name, as was done by Kukenthal, because we consider that the name *uncinata* is sufficiently distinct from *Uncinia*. Furthermore it is probable that article 55 of the International Rules will be amended at the Botanical Congress of 1930.

U. leptostachya Raoul.	Forest.
Carex pyrenaica Wahl.	Tussock.
C. virgata Sol.	Swamp.
C. stellulata Good.	Bog.

C. leporina Linn.	River-bed, swamp.
C. ternaria Forst.	Swamp.
**C. Berggreni* Petrie	(Recorded by Cheeseman).
C. inversa R. Br.	River-bed.
C. acicularis Boott.	Cushion plant formation.
C. dissita Sol. var. *monticola* Kuk.	Swamp, river-bed.
C. lagopina Wahl.	Senecio meadow.
C. Buchanani Berggr.	Scrub.
C. Sinclairii Boott.	Swamp.

CENTROLEPIDACEAE.

Gaimardia setacea Hook. f.	Bog.
G. ciliata Hook. f.	Bog.

JUNCACEAE.

Rostkovia (*Marsippospermum*) *gracilis* Hook. f.	Cushion plant formation, and fellfield.
Juncus polyanthemos Buchen.	Swamp.
J. lampocarpus Ehr.	Swamp.
J. tenuis Willd.	Swamp.
J. novae zealandiae Hook. f.	Bog, swamp.
Luzula Colensoi Hook. f.	Cushion plant formation.
L. pumila Hook. f.	Cushion plant formation.
L. campestris D.C. var. *Petriana* Buchen.	Scrub, tussock, river-bed, Senecio meadow.
L. campestris D.C. var. *picta* (A. Rich) Hook. f.	Forest.
L. leptophylla Buchen.	River-bed.

LILIACEAE.

Enargea parviflora (Kunth.) Skott.	Forest (Halpins Creek) and near top of pass.
Astelia Cockaynei Cheesem.	Forest, scrub.
A. Petriei Ckne.	Fellfield, tussock.
A. linearis Hook. f.	Bog.
Phormium Colensoi Hook. f.	Scrub.

ORCHIDACEAE.

Prasophyllum Colensoi Hook. f.	Bog, forest.
Pterostylis areolata Petrie.	Forest.
P. Oliveri Petrie.	Forest.
Lyperanthus antarcticus Hook. f.	Bog.
Caladenia bifolia Hook. f.	Bog, forest.
C. Lyallii Hook. f.	
Corysanthes rotundifolia Hook. f.	Forest.
C. triloba Hook. f.	Forest.
Thelymitra uniflora Hook. f.	Scrub (Blimit Peak)
Gastrodia Cunninghamii Hook. f.	Forest.
Chiloglottis cornuta Hook. f.	Damp rock in forest.

FAGACEAE.

Nothofagus cliffortioides (Hook. f.) Oerst.	Forest.

SANTALACEAE.

Exocarpus Bidwillii Hook. f.	Scrub in forest belt.

LORANTHACEAE.

Elytranthe tetrapetala (Forst.) Engl.	Forest, on Nothofagus cliffortioides and in one case on Dracophyllum longifolium.
E. flavida (Hook. f.) Engl.	Forest, on N. cliffortioides.

POLYGONACEAE.

Rumex flexuosus Sol.	Wet ground in river-bed, and bog on pass.
Muehlenbeckia axillaris Walp.	River-bed, forest.

PORTULACACEAE.

Claytonia australasica Hook. f.	Shingle slip, Senecio meadow, cushion plant formation.
Montia fontana Linn.	Running water.

CARYOPHYLLACEAE.

Stellaria gracilenta Hook f.	River-bed.
Stellaria parviflora. Banks et Sol. ex Hook. f.	Forest.
Colobanthus crassifolius Hook. f.	Senecio meadow.
C. acicularis Hook. f.	Cushion plant formation.

Some of the specimens collected possess five sepals, others four sepals. Whether the number of sepals is variable in this species or the specimens with four sepals should be referred to *C. monticola* Petrie we leave for future investigation.

Hectorella caespitosa Hook. f.	Fellfield.

RANUNCULACEAE.

Clematis australis Kirk.	Scrub, here only a scrambling plant.
Ranunculus Lyallii Hook. f.	Scrub, tussock, Senecio meadow.
R. Lyallii var. *Traversii* (Hook. f.) Cheeseman.	(Upper end of Rough Creek).
R. sericophyllus Hook. f.	Fellfield, Mt. Rolleston, 7000 ft. (Miss E. Washbourn).
R. hirtus Forst.	Wet ground.
R. rivularis Forst.	Swamp.
R. foliosus Kirk.	Senecio meadow.
R. tenuicaulis Cheesem.	Sub-alpine scrub.
Caltha obtusa Cheesem.	Senecio meadow.

CRUCIFERAE.

Cardamine heterophylla (Forst.) O. E. Schulz.	Forest.
C. heterophylla var. *uniflora* Hook. f.	Senecio meadow.

DROSERACEAE.

Drosera Arcturi Hook.	Bog.
D. spathulata Lab.	Bog.
D. stenopetala Hook. f.	Bog.

PITTOSPORACEAE.

Pittosporum tenuifolium Banks & Sol.	Forest. (Halpins Creek).
P. divaricatum Ckne.	Forest.

ROSACEAE.

Rubus australis Forst.	Forest.
R. schmidelioides A. Cunn. var. *coloratus* Kirk.	Forest.
Geum parviflorum Sm.	Forest, Senecio meadow.
G. uniflorum Buch.	Cushion plant formation.
Acaena microphylla Hook. f. var. *inermis* Kirk.	Forest edge.
A. Sanguisorbae Vahl var. *pilosa* T. Kirk.	Forest edge.
A. microphylla × *sanguisorbae.*	Forest edge.
A. saccaticupula Bitter.	Scrub, forest.
Potentilla anserina Linn. var. *anserinoides* (Raoul) Cheesem.	

LEGUMINOSAE.

Carmichaelia uniflora Kirk.	River bank by mouth of Graham's Creek, and mouth of Mingha.

GERANIACEAE.

Geranium microphyllum Hook. f.	River-bed.
G. sessiliflorum Cav.	River-bed.

OXALIDACEAE.

Oxalis lactea Hook.	Waterfall.

CORIARACEAE.

Coriaria sarmentosa Forst.	River-bed.
C. angustissima Hook. f.	River-bed.
C. sarmentosa × *angustissima* (*C. lurida*)	River-bed.

RHAMNACEAE.

Discaria toumatou Raoul.	Scrub on river-bed.

ELAEOCARPACEAE.

Aristotelia serrata (Forst.) W. R. Oliv.	Forest.
A. fruticosa Hook. f.	Forest, scrub.
A. serrata × *fruticosa* (*A. Colensoi*)	Forest.

MALVACEAE.

Hoheria glabrata Sprague & Summerhayes.	Forest, scrub.

VIOLACEAE.

Hymenanthera alpina Kirk.	Scrub.
Viola Cunninghamii Hook. f.	Scrub.
V. filicaulis Hook. f.	Forest.

THYMELEACEAE.

Pimelea prostrata (Forst.) Willd.	Scrub, river-bed.
Drapetes Dieffenbachii Hook.	Scrub, tussock.

Myrtaceae.

Myrtus pedunculatus Hook.	Forest on ridge.
Metrosideros umbellata Cav.	Scrub in forest belt.
Leptospermum scoparium Forst.	Scrub in forest belt.

Ongagraceae.

Fuchsia excorticata Linn. f.	Forest.
Epilobium erectum Petrie.	Forest.
E. pubens A. Rich.	Forest.
E. alsinoides A. Cunn.	Forest, tussock.
E. pedunculare A. Cunn.	Tussock; rocky ground, 5000 ft.
E. gracilipes Kirk.	River-bed.
E. crassum Hook. f.	Shingle slips.
E. pycnostachyum Haussk.	Shingle slips.
E. rubromarginatum Ckne.	Fellfield.
E. insulare Haussk.	Bog.
E. nummularifolium R. Cunn.	Damp scrub and bog.
E. novae-zealandiae Haussk.	(Specimens in Petrie Herbarium).
E. melanocaulon Hook.	River-bed.
E. microphyllum A. Rich.	River-bed.
E. glabellum Forst.	River-bed.
E. macropus Hook.	River-bed, Senecio meadow.
E. pictum Petrie.	Scrub.
E. chloraefolium Haussk.	Bog.

Haloragidaceae.

Haloragis depressa (A. Cunn.) Walp.	River-bed.
Gunnera dentata Kirk.	Forest.
G. prorepens Hook. f.	Swamp (McGraths Creek)
Myriophyllum propinquum A. Cunn.	In water on river-bed.

Araliaceae.

Nothopanax Colensoi (Hook. f.) Seem.	Forest, scrub.
N. simplex (Forst.) Seem.	Forest.
Pseudopanax lineare (Hook. f.) Laing & W. R. Oliv. n. Comb. (*Panax Lineare* Hook. f. Fl. Nov. Zel. 1, 93, 1853).	Forest.

We consider this species on account of its life history, best placed in the genus *Pseudopanax.*

P. crassifolium (Sol.) C. Koch. var. *unifoliolatum* T. Kirk.	Forest.

Umbelliferae.

Hydrocotyle novae zealandiae DC.	Fellfield.
Hydrocotyle sp.	Forest.

We are unable to refer this form which is fairly abundant to any described species and refrain from describing it as new, until the whole of the New Zealand species are revised.

Schizeilema pallidum (Kirk) Domin.	Swamp.
S. Haastii (Hook) Domin. and var. *cynopetalum* Domin.	Fellfield, forest, Senecio meadow.
Oreomyrrhis andicola Endl.	Senecio meadow.
Aciphylla crenulata J. B. Armstr.	Scrub, tussock.
A. similis Cheeseman.	Tussock, forest.
A. colensoi Hook. f. var. *maxima* Kirk.	Scrub, tussock.
Anisotome pilifera (Hook. f.) Ckne. & Laing.	Fellfield, tussock.
A. Haastii (F. Muell.) Ckne. & Laing.	Forest, scrub.
A. pilifera × *Haastii.*	
A. aromatica Hook. f.	Fellfield, tussock, scrub, forest.
A. imbricata (Hook. f.) Ckne.	Cushion plant formation.
Angelica montana (Forst.) Ckne.	Forest.

CORNACEAE.

Griselinia littoralis Raoul.	Forest.

ERICACEAE.

Gaultheria rupestris (Forst) R. Br.	Forest, scrub, tussock.
G. antipoda Forst.	Forest, scrub.
G. depressa Hook. f.	Cushion plant formation.
Pernettya nana Col.	By side of creek, 2,500 ft.

EPACRIDACEAE.

Pentachondra pumila (Forst) R. Br.	Bog, scrub, tussock, forest.
Cyathodes pumila Hook. f.	Bog.
C. empetrifolia Hook. f.	Forest.
Leucopogon Fraseri A. Cunn.	Scrub in forest zone, and river-bed.
Archeria Traversii Hook. f.	Forest.
Dracophyllum Traversii Hook. f.	Forest, scrub.
D. longifolium (Forst) R. Br.	Forest, scrub.
D. rosmarinifolium (Forst) R. Br. (= *D. uniflorum* Hook. f.)	Scrub, bog, forest.
D. longifolium × *rosmarinifolium* (*D. acicularifolium* (Cheesem.) Ckn.)	Scrub, tussock.
D. Kirkii Berggr.	Scrub.
D. pronum W. R. Oliv.	Fellfield, scrub, tussock.
D. Kirkii × *pronum* (*D. saxicolum*)	Scrub, tussock.

MYRSINACEAE.

Suttonia divaricata (A. Cunn.) Hook. f.	Forest, scrub.
S. nummularia Hook. f.	Forest, bog, scrub.

Gentianaceae.

Gentiana patula (Kirk) Cheesem.	Senecio meadow, scrub.
G. bellidifolia Hook f.	Bog, tussock, Senecio meadow, fellfield; Mt. Rolleston, 7,000 ft. (A. Anderson).
G. bellidifolia Hook. f.	Near top of pass by wayside.

Boraginaceae.

Myosotis pygmaea Col.	Senecio meadow.
M. Forsteri Lehm.	Damp forest and scrub.
M. explanta Cheesem.	Damp sub-alpine rocks.

Scophulariaceae.

Mazus radicans (Hook. f) Cheesem.	Forest.
Hebe salicifolia (Forst.) Pennell.	Forest edge.
H. subalpina (Ckne) Ckne & Allan.	Scrub, forest.
H. vernicosa (Hook. f.) Ckne & Allan.	Forest, tussock, scrub.
H. ciliolata (Hook. f.) Ckne & Allan.	Tussock.
H. lycopodioides (Hook. f.) Ckne & Allan.	Tussock.
H. Haastii (Hook. f) Ckne & Allan var. *macrocalyx* (J. B. Armstr.).	Fellfield; Mt. Rolleston, 7,000 ft. (Miss E. Washbourn).
H. epacridea (Hook. f.) Ckne & Allan.	Forest by creek.
H. macrantha (Hook. f.) Ckne & Allan.	Scrub, tussock.
H. buxifolia (Benth) Ckne & Allan.	Tussock, scrub, bog.
H. buxifolia var. *pauciramosa* Ckn. & Allan.	Senecio meadow.
Pygmaea pulvinaris Hook. f.	Fellfield.
Veronica Lyallii Hook. f.	River-bed.
V. Bidwillii Hook.	River-bed.
V. linifolia Hook. f.	River-bed on wet rocks.
Ourisia macrocarpa Hook. f. var. *calycina* (Col) Ckne.	Scrub.
O. Crosbyi Ckne.	Forest.
O caespitosa Hook. f.	Scrub, creek bank in forest.
O. sessilifolia Hook. f.	Tussock; Mt. Rolleston, 7,000 ft. (A. Anderson).
Euphrasia revoluta Hook. f	Tussock.
E. Laingii Petrie.	River-bed in forest.
E. zealandica Wettst.	Bog.
E. Cockayniana Petrie.	Bog

Plantaginaceae.

Plantago Brownii Rapin.	Senecio meadow.
P. lanigera Hook. f.	Scrub.
P. triandra Berrgi.	Wet roadside and swamp.

LENTIBULARIACEAE.

Utricularia monanthos Hook. f.	Bog.

RUBIACEAE.

Coprosma serrulata Hook. f.	Forest, scrub.
C. lucida Forst.	Forest (Halpins Creek).
C. rugosa Cheesem.	Forest, scrub.
C. brunnea (Kirk) Ckne.	River-bed.
C. ramulosa Petrie.	Forest.
C. linariifolia Hook. f.	Forest.
C. pseudocuneata W. R. Oliv. *ined* (= *C. cuneata* Auct. not Hook. f.)	Forest, scrub.
C. crenulata W. R. Oliv. (= *C. retusa Petrie. See Trans. N.Z. Inst.*, Vol. 49, p. 153, 1917).	Bog, bog forest.
C. parviflora Hook. f.	Forest, scrub.
C. propinqua A. Cunn.	Forest.
C. ciliata Hook. f.	Forest, scrub.
C. foetidissima Forst.	Forest.
C. depressa Col.	Scrub.
C. repens Hook. f.	Scrub.
Nertera setulosa Hook. f.	Rocks in forest.
Asperula perpusilla Hook. f.	River-bed.
Galium umbrosum Sol.	Wet ground in river-bed.

CAMPANULACEAE.

Pratia angulata (Forst) Hook. f.	Creek-bed in forest.
P. macrodon Hook. f.	Fellfield, tussock.
Wahlenbergia albomarginata Hook.	Tussock, river-bed.

STYLIDIACEAE.

Donatia novae zealandiae Hook. f.	Bog.
Phyllachne Colensoi (Hook. f.) Berggr.	Cushion plant formation.
Forstera sedifolia Linn. f.	Bog and rock.
F. tenella Hook. f.	Forest.

COMPOSITAE.

Lagenophora petiolata Hook. f.	Forest, tussock.
Brachycome Sinclairii Hook. f.	Tussock, scrub, Senecio meadow.
Olearia Colensoi Hook. f.	Scrub.
O. arborescens (Forst) Ckne & Laing.	Forest.
O. ilicifolia Hook. f.	Scrub.
O. arborescens × *ilicifolia* (*O. macrodonta*)	Scrub.
O. avicenniaefolia (Raoul) Hook. f.	Forest.
O. lacunosa Hook. f.	Forest.
O. lacunosa × *ilicifolia.*	Scrub.
O. Haastii Hook. f.	Forest by river.
O. nummularifolia (Hook. f.)	Forest, scrub.
Celmisia Walkeri Kirk.	Tussock.

C. incana Hook. f.	Tussock, scrub.
C. novae-zealandiae (Buch) Cheesem.	Forest, bog, tussock, scrub.
C. discolor Hook. f.	Forest, tussock, bog.
C. coriacea Hook. f.	Scrub, tussock.
C. Armstrongii Petrie.	Scrub, tussock, bog.
C. spectabilis Hook. f.	Scrub, tussock.
C. petiolata Hook. f.	Scrub, tussock, Senecio meadow.
C. Haastii Hook. f.	Scrub, tussock, Senecio meadow.
C. gracilenta Hook. f.	Swamp, forest.
C. alpina (Kirk) Cheesem.	Bog.
C. gracilenta × *spectabilis.*	Forest.
C. glandulosa Hook. f.	Bog.
C. bellidioides Hook. f.	By creek in forest.
C. sessiliflora Hook. f.	Tussock.
C. laricifolia Hook. f.	Fellfield, tussock.
C. linearis J. B. Armstr.	Bog.
Haastia Sinclairii Hook. f.	Shingle slips.
Gnaphalium luteo-album Linn.	By creek in forest.
Raoulia subulata Hook. f.	Fellfield.
R. australis Raoul.	River-bed.
R. Haastii Hook. f.	River-bed.
R. tenuicaulis Hook. f.	River-bed.
R. glabra Hook. f.	River-bed.
R. grandiflora Hook. f.	Fellfield, tussock.
Helichrysum bellidioides (Forst) Willd.	Senecio meadow, river-bed.
H. filicaule Hook. f.	By side of creek and dry forest.
H. depressum (Hook. f.) Benth & Hook. f.	River-bed.
H microphyllum (Hook. f.) Benth & Hook. f.	Wet cliffs in forest.
Cassinia Vauvilliersii (H. & J.) Hook. f.	Forest, scrub.
Craspedia uniflora Forst.	River-bed, scrub, Senecio meadow.
Cotula pyrethrifolia Hook. f.	Forest, tussock, fellfield.
C. squalida Hook. f.	Forest.
Leucogenes grandiceps (Hook. f.) Beauv.	Fellfield, tussock, shingle slips.
Erechtites glabrescens Kirk.	Forest.
Abrotanella linearis Berggr.	Fellfield.
Senecio lagopus Raoul.	River-bed.
S. bellidioides Hook. f.	Forest, bog, scrub.
S. Lyallii Hook. f.	Senecio meadow, tussock.
S. scorzonerioides Hook. f.	Tussock.
S. Lyallii × *scorzonerioides.*	Tussock, Senecio meadow.
S. elaeagnifolius Hook. f.	Forest, scrub.
S. Bidwillii Hook. f.	Scrub.
S. elaeagnifolius × *Bidwillii.*	Forest.
Microseris scapigera (Forst) Hoffm.	Swamp, wet rocks.
Taraxacum magellanicum Comm.	Fellfield.

Contributions for a Revision of the Crustacea Brachyura of New Zealand.

By CHAS. CHILTON, M.A., D.Sc., F.N.Z.Inst., etc., and E. W. BENNETT, M.Sc.*

[*Read before the Philosophical Institute of Canterbury, 7th November, 1928; received by the Editor, 5th December, 1928; issued separately, 25th March, 1929.*]

THE authors of this paper intended to prepare a comprehensive monograph on the New Zealand Brachyura, but a severe limitation of the time available for the work has made it necessary for the results of the study to be presented in a much more fragmentary form. This will explain the unequal attention that has been paid to the various species, some of which have been studied in considerable detail, while others have been left aside altogether. We trust, however, that the present contributions will facilitate the study of collections in local museums and elsewhere, for such work would readily provide valuable data concerning several pressing problems and gaps in our knowledge.

One of these problems concerns the many species whose occurrence in the New Zealand Region is doubtful. Certain species are definitely known to have been wrongly recorded as coming from New Zealand waters, and others are under suspicion; but it is difficult to demonstrate that a given species is not a member of the fauna, and a premature dismissal is liable to add to the difficulties and to lead to undesirable complications when such a species is subsequently found. For these reasons we have not indulged in such a wholesale purging of the list as would have been necessary in the more complete monograph which we originally intended to write.

The material before us consists of some 330 jars and tubes of New Zealand Brachyura, in addition to a representative dried collection and miscellaneous foreign specimens. Some of the material has already been reported upon by the senior author, particularly those of the expeditions to the Subantarctic Islands, to the Kermadecs, and along the east coast in the "Nora Niven"; the interesting freshwater *Hymenosoma* has been the subject of several memoirs; and MS. notes have been drawn up from the collections secured by the senior author for many years from all parts of New Zealand—partly from correspondents, and partly from personal collecting, especially during a cruise in the Government steamer "Hinemoa" in 1914-1915, during the visit to New Zealand of Dr. Th. Mortensen, Zoologist of the Copenhagen Museum. The junior author has also personally col-

*The compilation of this paper is almost entirely the work of Mr. E. W. Bennett, the "junior author." Owing to his appointment to a position in the Zoological Department of the University of Western Australia, Perth, it had to be completed in a very limited time and there has been little opportunity of discussing with him many of the points under consideration. —CHAS. CHILTON.

lected Brachyura for several years, particularly from the east coast of the South Island. The rest of the material consists of the collections of the Canterbury Museum, including amongst other miscellaneous material a set of dried exhibit specimens named by Hutton. The whole of our collections, including some type specimens, has now been deposited in the Canterbury Museum.

It will be seen that the material available includes collections from all parts of the New Zealand region except the Kermadec Islands,* and contains dredged as well as intertidal specimens. It is therefore fairly representative of the New Zealand Brachyurous fauna. But no collection is ever sufficiently complete, and we have, for example, not felt justified in excluding the doubtful species from the list because they are not represented in our collections. A comparison of our findings on such genera as, for example, *Cyclograpsus* and *Helice* will show the necessity for cautiousness in this direction; but the doubtful species in Hutton's "black list" (see below) may be regarded as having been given their last chance in the present paper, and if they are not recognised in the other collections in the country, particularly those from deeper water and less familiar districts, they may henceforth be rejected without compunction.

A brief survey of previous work will serve to illustrate not only the progress of our knowledge, but also the reasons for the doubt that exists concerning so many species. Among the earliest writers who contributed reports on Brachyura, including those of New Zealand, are Milne-Edwards, who described the collections of Quoy and Gaimard; Dana, who accompanied the United States Exploring Expedition; Jacquinot and Lucas, who described the Brachyura of the so-called "Voyage au Pôle Sud"; and Heller, the naturalist of the "Novara" expedition. These reports, written for old-world carcinologists rather than for New Zealand workers, were additions to the European literature rather than monographs on the New Zealand crab-fauna, and local workers were greatly aided by the publication in 1876 of Miers' *Catalogue of the New Zealand Crustacea.*" This is the only attempt that has yet been made to gather together what is known of the New Zealand Brachyura, or of the local Crustacea in general. It contained definitions of all the species, genera, and higher groups known or thought to occur in this country; and it added a number of species to the list, including some which were new to science—the latter being first described in the *Ann. Mag. Nat. Hist.*, ser. 4, vol. 17, 1876, and figured in the Catalogue. The absence of figures of previously-known species detracted from the completeness of the work to some extent, but a much more serious defect was the inclusion of a number of species which do not occur in our waters. The latter was no fault of Miers, who (as Hutton remarked) had to record all the species reported to have come from New Zealand; but the fault lay with those who had mixed the labels in so many cases, and who had previously published incorrect records. The worst offender in the latter respect was Heller, whose locality-records are unreliable.

This source of confusion was not expressly dealt with by Filhol in his report on the *Mission de l'Ile Campbell;* but this author based

*The Brachyura of the Kermadec Islands have not been included as they are Australian rather than New Zealand.

his work on excellent material and so did not add to the confusion, though he listed all the species in the Catalogue without criticism. Filhol's material consisted of his personal collections and of a few specimens presented by local naturalists, and of those in the Paris Museum which had already been described by Milne-Edwards. A fine atlas of plates went far towards remedying what was felt to be a drawback in Miers' Catalogue.

A further source of confusion, too obvious to cause much real difficulty, has been the tendency of a few writers to identify our species with those of Europe, depending on the briefest descriptions.

In a short paper published in 1882 in the *N.Z. Journal of Science*, p. 263, Hutton drew attention to the unreliable nature of many of these records. He gave a list of species which should certainly be excluded, another of species which should probably also be excluded, and a third list of those whose occurrence in this country had not been verified. These conclusions were corroborated in a brief note published in the same volume by the Hon. G. M. Thomson (l.c., p. 333), who has paid much attention to these Crustacea. In the report on the Crustacea collected during the expedition of H.M.S. "Alert", Miers repeated several of these records, but was evidently unaware of the criticism of his Catalogue by local workers. These records have also been repeated by Ortmann (1894) and several other workers abroad. A few of the species which Hutton regarded as doubtful have been found again, but his list appears to have been remarkably well chosen; in very few cases, for example, does the list drawn up by G. M. Thomson and C. Chilton for the *Index Faunae Novae Zealandiae*, published many years later, differ from these earlier views. In the list below we have not included the species which Hutton and Thomson wished to exclude, except where there is further evidence; but we have retained most of the doubtful ones as still doubtful. In the synonymy of the various species we have not quoted the *Index Faunae N.Z.* and Hutton's critical lists, but when they contain an opinion which is still of weight we have drawn attention to them in our notes.

It need hardly be stated that the "Challenger" reports contain a valuable addition to our knowledge. The collections of Brachyura were entrusted to Miers, whose previous knowledge of our Brachyurous fauna was of some advantage; nevertheless, as only a few Crustacea were collected in New Zealand the report was hardly of such outstanding importance to New Zealand workers as the reports on other groups of animals less confined to the littoral. Subsequent descriptive work has been confined almost entirely to the writings of the senior author, as mentioned above; but special mention should be made of a paper on the "Biology of Otago Harbour" by the Hon. G. M. Thomson (*Trans. N.Z. Inst.*, vol. 45), who has devoted a section of the paper to notes on the occurrence and habits of the Brachyura of the coasts of Otago.

In the present survey, our aim has been to state the problems rather than to attempt to solve them. In no case has a decision been given without a full statement of the grounds on which it is based, and the extent to which, in our opinion, it may be relied upon. The way is thus left clear for further revision. Certain genera have not

been touched upon, namely, *Paramithrax,* of which the Canterbury Museum contains an extensive series; *Pilumnus,* a difficult genus of which the collections contain some forms new to science or at least to New Zealand; and the smaller crabs of the genera *Pinnotheres, Halicarcinus, Hymenicus, Hymenosoma, Elamena,* and *Ebalia.*

The Canterbury Museum library contains some papers formerly belonging to Hutton, and annotated by him; most of his comments have already been published in the critical paper mentioned above, but we have quoted and duly acknowledged several others below. It may be noted that in his copy of his critical paper, he has corrected the word "typical" (p. 264, line 9) to "tropical," which was the word originally intended.

In our lists of localities below, it is to be understood that some of the personal names after the records refer to collectors whose specimens we have seen and identified, and some to authors from whom the record is quoted; the latter is the case when the author in question has contributed a paper which is quoted in the synonymy of the species in question. When it is not expressly stated that records on the authority of Hutton are based on his MSS., it is to be understood that he has left labelled specimens in the Canterbury Museum. Specimens which we have personally collected are indicated by our respective initials only, and the full name of the senior author refers to a previously published record.

As regards the evidence afforded by the Brachyura of the geographical relationships of the New Zealand region, our knowledge of the group is still much too imperfect for very precise deductions to be drawn. There are about eleven species which are known only from the original description, and which are in some cases open to doubt; if they are included among the endemic element, the latter constitutes two-thirds of the species whose validity and occurrence in New Zealand are beyond reasonable doubt, and if they are excluded, the proportion is still one-half. This is a high proportion in a group with such means of dispersal in the adult and larval stages. As is natural, the list of names of foreign species which have been recorded, though in all probability incorrectly recorded, from New Zealand, includes a high proportion of Australian and Indo-Pacific forms; but nevertheless there still remains, after these have been subtracted, a strong Australian element—which, in fact, is stronger than any other element except the endemic. Some of these species occur, as far as is known, only in Australia and New Zealand (*Nectocarcinus integrifrons, Ommatocarcinus macgillivrayi, Gyclograpsus lavauxi, Helice crassa,* not to mention some doubtful examples); others are found also in the Kermadecs and other islands to the north of New Zealand (*Ozius truncatus*); and others again are confined to these islands and New Zealand, and do not occur in Australia (*Heterozius rotundifrons, Cyclograpsus whitei*). It is not easy to discover the source of these species, but geographically they appear to form a natural group whereby the New Zealand fauna is linked with the Australian.

There is also a more or less cosmopolitan element (*Ovalipes bipustulatus, Planes minutus*) whose members have special means of dispersal, and cannot be employed in any argument concerning origins and relationships.

As for the southern forms, a few species (*Leptomithrax australis, Prionorhynchus edwardsi*) are more common around the Auckland and Campbell Islands than near the mainland; but the absence of species endemic to these islands supports Dr. Th. Mortensen's recent conclusions (*Saertryk af Vidensk. Medd. fra Dansk. naturh. Foren*, Bd. 79, 1925), based on his study of the New Zealand Echinoderms, that the islands in the south are strictly a part of the New Zealand region, and in that sense not truly subantarctic. There is, however, a small but true southern element, represented by *Hemigrapsus crenulatus, Halicarcinus planatus,* and *Cancer novae-zealandiae,* with distinct South American affinities; while *Leptograpsus variegatus* and *Plagusia chabrus* occur not only in South America but in Australia and to the north, and possibly represent a former subantarctic element which is spreading into the Indo-Pacific.

To sum up the argument, the evidence from the Brachyura dealt with in this paper is open to considerable doubt, partly because of our imperfect knowledge of the group and partly because of their means of dispersal; but it agrees with Dr. Mortensen's chief conclusions, that the New Zealand region, including the southern islands, is a very distinct area, with clear evidence of former relationships with Australia, and less pronounced indications of affinities with South America and the Subantarctic.

Stenorhynchus fissifrons Haswell.

Stenorhynchus fissifrons Haswell, *Proc. Linn. Soc. N.S.W.*, vol. 3, p. 409. 1879.
—— Haswell, *Cat. Crust. Austr.*, p. 2. 1882.
Achaeopsis (?) *fissifrons* Miers, *Challenger Reports*, Zool., vol. 17, Crust., pp. 6, 18. 1886.

Only the type specimen, a female, is known from New Zealand; it is said by Haswell to have been deposited in the Macleay Collection, which is now at Sydney University, but a half-day search by the junior author failed to discover it.

Locality.—Auckland (Haswell).
Distribution.—Port Jackson, Australia (Haswell).
Type.—(See above).

Huenia bifurcata Streets.

Huenia bifurcata Streets, *Proc. Acad. Nat. Sci., Philad.*, p. 107. 1870.
—— Miers, *Cat. Crust. N.Z.*, p. 3. 1876.
—— Haswell, *Cat. Crust. Austr.*, p. 8. 1882.
—— Filhol, *Mission de l'Ile Campbell*, p. 352. 1885.
Simocarcinus (?) *bifurcata* Miers, *Challenger Reports*, Zool., vol. 17, Crust., p. 35. 1886.
Huenia bifurcata Fulton and Grant, *Proc. Roy. Soc. Vict.*, vol. 19, pt. 1, p. 17, 1909.

The type specimen is the only one recorded from New Zealand, and the species is one whose occurrence here was considered by Hutton to be very doubtful. It does not appear to be the same as the

widely-spread and very variable *H. proteus* de Haan (known from Japan, China, Australia, Kermadec Islands).

Locality.—N.Z. (Streets).
Distribution.—Australia.
Type.—Mus. Acad. Nat. Sci., Philadelphia.

Trichoplatus huttoni A. Milne-Edwards.

Trichoplatus huttoni A. Milne-Edwards, *Bull. Soc. Phil.*, 12th Feb., 1876.
—— A. Milne-Edwards, *Ann. Sci. Nat.*, ser. 6, t. 4, art. 9, Pl. 10. 1876.
Halimus hectori Miers, *Ann. Mag. Nat. Hist.*, ser. 4, vol. 17, p. 219. 1876.
—— Miers, *Cat. Crust. N.Z.*, p. 4, Pl. 1, Fig. 1. 1876.
Halimus rubiginosus Kirk, *Trans. N.Z. Inst.*, vol. 13, p. 236. 1881.
—— Filhol, *Mission de l'Ile* Campbell, p. 352. 1885.
Trichoplatus huttoni Filhol, l.c., p. 352. 1885.
—— Hector, *Trans. N.Z. Inst.*, vol. 9, p. 474. 1877.
—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 236. 1913.

It has been recognised by all writers, including Miers and Milne-Edwards, that the species described by those authors are identical, and we have taken the further step of uniting Kirk's name also as a simple synonym of Milne-Edwards', for the following reasons:

Kirk was unaware of the work of Milne-Edwards, though he wrote several years later; the briefness of Miers' description and the poorness of his figure, due to the mutilated condition of the only specimen in the British Museum, explain why Kirk distinguished another supposed species, but if he had seen the careful description and the figure given by Milne-Edwards he would hardly have taken that step. It is obvious that Kirk's species is the same as Milne-Edwards', and though less obvious it is quite certain that Miers' is also the same.

The reasons which influenced Kirk were as follows: A drawing of his specimen was forwarded by Hector to Miers, who replied that it was evidently closely related, "the tubercles occupying the same positions, but being in some places replaced by spines, also the rostral spines are longer and more acute. These differences may be due to age or sex. . . . Only an actual comparison of your variety with the type of *H. hectori* would enable me to determine whether it is really distinct" (Hector 1877, p. 474). The differences were found by Kirk not to be due to age or sex, and disregarding Miers' added caution, and evidently not realising the imperfection of Miers' figure and description, he proposed the new species. Miers' comments may be accounted for; the tuft of hairs on the tubercles might well give the latter a spinous appearance in a drawing, and the rostral spines of Miers' figure are shorter than in any subsequently recorded specimens, including our present series. Curiously enough, Kirk did not include these characters in his diagnosis, but gave characters which, especially in the absence of a figure, can be regarded only as inadequate.

Thus in our opinion *Halimus hectori* Miers and *H. rubiginosus* Kirk are the same, and are synonyms of *Trichoplatus huttoni* Milne-Edwards.

The hand is smooth in the male, much smaller, grooved, and hairy in the female. The carapace, except the frontal and hepatic regions, and also the walking-legs, are finely pubescent. The colour is a dark brown.

Some of the hairs are coiled round and serve to hold fragments of seaweed (of the same colour as the animal) in the same manner as keys are fastened on a split ring. The seaweed is not growing or rooted on the hairs, but pierced by the latter, so that it is probably renewed from time to time. *H. spinosus* Hess (Kermadec Islands) and probably other species have the same habit.

Locality.—N.Z. (Milne-Edwards, Miers).
Sumner (Hutton).
Akaroa Heads (J. W. Arthur).
Wellington, Cape Campbell, Napier (T. Kirk).
Cook Strait; east coast of Otago (Filhol).
Stewart Island (W. Traill).
Kaikoura (E.W.B.).
"Occasionally met with in Otago Harbour and on the coast, especially after heavy north-easterly weather." (Thomson).

The species appears to be widely distributed in New Zealand, but nowhere common.

Distribution.—Endemic.
Type.—Paris Museum.

Halimus diacanthus (de Haan).

Pisa (*Naxia*) *diacantha* de Haan, *Fauna japonica,* Crust., p. 96, Pl. 24, Fig. 1. 1839.
Hyastenus verreauxii A. Milne-Edwards, *Nouv. Archiv. Mus. Hist. Nat.,* Paris, vol. 8, p. 250. 1872.
Hyastenus diacanthus A. Milne-Edwards, *tom. cit.,* p. 250. 1872.
—— Miers, *Cat. Crust., N.Z.,* p. 9. 1876.
—— Miers, *P.Z.S.,* pp. 19, 26. 1879.
—— Haswell, *Cat. Austr. Crust.,* p. 20. 1882.
—— Miers, Zool. H.M.S. "Alert," p. 194. 1884.
—— Filhol, *Mission de l'Ile Campbell,* p. 366. 1885.
—— Miers, *Challenger Reports,* Zool., vol. 17, pp. 56, 57. 1886.
—— Rathbun, *Proc. U.S. Nat. Mus.,* vol. 6, p. 85. 1893.
—— Ortmann, *Zool. Jahrb.,* vol. 7, p. 55. 1894.
—— Ortmann, *Zool. Forschungsreisen in Austr.,* vol. 5, p. 42. 1894.
Halimus diacanthus Rathbun, *Proc. Biol. Soc. Washington,* vol. 11, p. 157. 1897.

Hutton regarded the occurrence of this species in New Zealand as "very doubtful," and did not include it in the *Index Faunae N.Z.* Ortmann's statement that it does occur is evidently a quotation from Haswell's Catalogue, which in turn depends on Miers and the unreliable labels of specimens in the British Museum. The New Zealand collections which we have seen contain nothing like it.

Locality.—N.Z. (Miers).
Distribution.—Australia, Philippine Islands, Japan.

Paramithrax.

We have not included this genus in the present survey, and without a revision of the New Zealand representatives we have refrained from assigning our specimens, which are numerous, to the species previously recorded, and therefore do not attempt to give new localities for them. The following species have been recorded from New Zealand, the first three being the commonest:—

Paramithrax peronii Milne-Edwards; Miers, *Cat. Crust., N.Z.*, p. 5.
Paramithrax latreilli Miers (= *P. cristatus* Filhol = *P. barbicornis* Miers, not of Latreille); *Mission de l'Ile Campbell,* p. 358.
Paramithrax longipes Thomson; *A.M.N.H.* 7, 10, p. 361.
Paramithrax minor Filhol; *Mission de l'Ile Campbell,* p. 356.
Paramithrax sternocostulatus Milne-Edwards (=*P. gaimardi Miers*); *Cat. Austral. Crust.*, p. 13.
Paramithrax parvus Borradaile, *Brit. Antarct. Exped.* 1910, Zool., vol. 3, p. 105.

Leptomithrax australis (Jacquinot and Lucas).

Maia australis Jacquinot and Lucas, *Voyage au Pole Sud,* Zool., vol. 3, Crust., p. 11, Pl. 2, Fig. 1. 1853.
Leptomithrax australis Miers, *Cat. Crust. N.Z.*, p. 7. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 361, Pl. 38. 1885.
—— Chilton, *Subant. Isl. N.Z.*, vol. 2, p. 607. 1909.
—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 237. 1913.
—— Stephensen, *Dr. Th. Mortensen's Pacific Exped.* 1914-16, vol. 40, p. 292. 1927.
(Not *L. australiensis* Miers, *Ann. Mag. Nat. Hist.*, ser. iv, vol. 17, p. 220).

The genus *Leptomithrax* is most readily distinguished from *Paramithrax* by the presence of tubercles but no ridge on the wrist of the former, while the wrist of the latter is strongly ridged. In young *Leptomithrax* (about an inch in length), there is, however, a nodulous ridge. The differences between *L. australis* and *L. longimanus* are very distinct and may be stated as follows:—

	L. australis.	*L. longimanus.*
Spine at outer corner of orbital cavity	With small accessory spine at base.	Without accessory spine.
Granules on arm and wrist	On upper and outer surfaces only.	Over the whole of the joints.
Inner edge of fixed finger	Denticulated for more than half the length, the denticulations extending over the broad curve at the middle into the excavation in the proximal half of the finger.	Denticulations stopping short at the middle of the finger, where the excavation begins; end of the excavation sharply angled.

In addition, the arms and hands of *L. longimanus* are much longer, the legs are stouter, and the branchial regions more inflated at the sides than in the case of *L. australis.*

In young specimens and in the female, the fingers fit closely together along their whole length; there is neither excavation nor inner tubercle.

In his copy of the N.Z. Journal of Science, vol. 1, Hutton has deleted this species from the list of those whose occurrence he formerly considered doubtful; and in Miers' Catalogue he has appropriately noted that the carapace is "spinulose" rather than "covered with smooth tubercles."

Locality.—Auckland Islands (Jacquinot and Lucas, Stephensen); "Aurora" (specimens in the Canterbury Museum).
Dunedin (Hutton).
Hauraki Gulf, 50 fathoms (G. E. Archey).
"Not uncommon on the coast (Otago). Occasionally taken on the sand-banks by the seine net." (Thomson).
Off Little Barrier, 35 fathoms (C.C.)

Distribution.—Endemic.

Leptomithrax longimanus Miers.

Leptomithrax longimanus Miers, *Ann. Mag. Nat. Hist.*, ser. 4, vol. 17, p. 220. 1876.
—— Miers, *Cat. Crust. N.Z.*, p. 8, Pl. 1, Fig. 3. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 364, Pl. 39, Fig. 4. 1885.

Filhol did not expressly criticise the diagnostic features emphasized by Miers, viz., that the species is "at once distinguished by the great length of the anterior legs, and by the absence of spines on the antero-lateral margins." What Miers may have meant concerning the spines is obscure, and Filhol's account is more accurate, viz., that except for the absence of the small accessory spine on the post-ocular spine, the spines of the carapace occupy the same positions as in *L. australis.* The spines, in fact, are stout, though not as long or as sharp as in the latter species. As for the "great length of the anterior legs," it is not known whether this applies to the female.

The pubescence mentioned by Miers is apparently transient, and the "small scattered granules" are more accurately described by Hutton (MS.) as "flattened tubercles."

Our largest specimen, a male, slightly exceeds Filhol's, the proportions of the various dimensions being the same as those quoted by him. They are as follows:—

Length of carapace (including rostral spines)	50 mm.
Breadth of carapace	40 mm.
Length of rostrum	7 mm.
Length of hand	46 mm.
Length of arm, measured from cephalothoracic margin	97 mm.

We have several small females from off Cape Maria. The dimensions of the largest, which bears no eggs, are as follows:—

Length of carapace	30 mm.
Breadth of carapace	21 mm.
Length of arm	33 mm.
Length of hand	16 mm.
Length of first legs	34 mm.

The arm is therefore only as long as the first legs or the carapace, whereas in the adult male it is twice as long. This may be attributed to age rather than to sex, as shown by still smaller males in our collection; so that the adult female is still unknown. In our small specimens the eyes are prominent, rostral spines divergent, ambulatory legs with long and shorter hairs, including a row of hooked hairs along the upper margins; the whole exoskeleton covered with a fine pubescence, except the arms, which are smooth and slender, wrist scarcely granular, fingers thin, fixed finger with faint sign of excavation.

Postscript.—In writing the above, we overlooked Borradaile's description of *Paramithrax* (*Leptomithrax*) *affinis;* from a comparison of the texts, we consider it likely that our small specimens from Cape Maria may belong to Borradaile's species (see next species).

Locality.—N.Z. (Miers).
Sumner (Hutton).
Stewart Island, 30 fathoms (Filhol).
Puysegur Point, Stephens Island (T. B. Smith).
Dunedin (Austr. Mus., Sydney).
10 miles N.W. from Cape Maria; Little Barrier, 35 fathoms (C.C.).

Distribution.—Endemic.

Leptomithrax affinis Borradaile.

Paramithrax (*Leptomithrax*) *affinis* Borradaile, *Brit. Ant. Exp.*, Zool., vol. 3, p. 104, Fig. 14. 1916.

This species has been created by Borradaile for a single female specimen, which he considers distinct from *L. longimanus,* though admittedly closely related to it. We have not compared Borradaile's description with some young specimens which we have identified with *L. longimanus* (see postscript to that species), but they appear to agree well, especially as regards the chelipeds and the spines of the rostrum. We have noted above that the chelipeds of young specimens of both New Zealand species of *Leptomithrax* (according to our identification) are intermediate between those of adult *Paramithrax* and *Leptomithrax,* and this may be Borradaile's reason for placing his species and *L. longimanus* in a subgenus of *Paramithrax.* The localities of our young specimens and Borradaile's species agree well, and *L. longimanus* is known, apart from our record, only from much more southern localities. But while we have drawn attention to the differences between these small females and adult males, we have preferred to regard them as due to age and sex, for the adult female

of *L. longimanus* is otherwise unknown. Borradaile's specimen was small and evidently not egg-bearing; he admits that the differences in the chelipeds at least may be due to sex, and he describes the species with some degree of doubt. Under the circumstances, it appears quite possible that *L. affinis* is a synonym of *L. longimanus*.

Locality.—Near Three Kings Islands, 100 fathoms. (Borradaile).

Distribution.—Endemic.

Type.—Brit. Mus.

Echinomaia hispida Borradaile.

Echinomaia hispida Borradaile, *Brit. Antarct. Exped.* 1910, Zool., vol. 3, p. 104. 1916.

This very interesting addition to the list is based on two male specimens, for which Borradaile has founded a new genus and species.

Locality.—Near Three Kings Islands, 100 fathoms (Borradaile).

Distribution.—Endemic.

Type.—British Museum.

Acanthophrys filholi A. Milne-Edwards.

Acanthophrys filholi A. Milne-Edwards, *Bull. Soc. philomatique.* 1876.

—— A. Milne-Edwards, *Ann. Sci. Nat.*, ser. 6, vol. 4, art. 9, p. 4. 1876.

—— Filhol, *Mission de l'Ile Campbell,* p. 365, Pl. 39, Figs. 1-3, Pl. 40, Fig. 8. 1885.

—— Chilton, *Rec. Canterbury Museum*, vol. 1, no. 3, p. 290. 1911.

—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 237. 1913.

? *Chlorinoides filholi* Miers, *Challenger Reports,* Zool., vol. 17, p. 52. 1886.

Filhol has copied *in toto* the description given by Milne-Edwards, and has added a figure, but little else. The female has therefore not hitherto been characterized; but specimens in our collections show that it agrees with the male, except that the flanges on the arm are not as exaggerated and the teeth are not as prominently denticulated; the female arm and hand are much smaller than those of the male.

We can verify Filhol's remark that the species is "very remarkable for the enormous quantities of algae, bryozoa, sponges, and ascidians, which live fastened on to the numerous hairs covering the carapace."

Locality.—Stewart Island (Milne-Edwards).
Stewart Island, on oyster-beds, very abundant (Filhol).
Nora Niven, Stations 17, 26, 44 (Chilton).
New Brighton, drift (H. Suter).
10 miles N.W. off C. Maria; off West King, 60-65 fathoms (C.C.).

Distribution.—Endemic.

Type.—Paris Museum.

Paramicippa spinosa Stimpson.
(**Paramicippa spinosa** var. **affinis** Miers.)

Paramicippa spinosa Stimpson, *Proc. Acad. Nat. Sci. Philadelphia,* p. 217. 1857.
Paramicippa affinis Miers, *Cat. Crust. N.Z.*, p. 9. 1876.
Paramicippa spinosa Haswell, *Cat. Crust. Austr.*, p. 26. 1882.
—— Miers, Zool. H.M.S. "Alert," p. 199. 1884.
—— Filhol, *Mission de l'Ile Campbell,* p. 367. 1885.
Paramicippa spinosa var. *affinis* Miers, *Ann. Mag. Nat. Hist.*, ser. 5, vol. 15, p. 8. 1885.
—— Miers, *Challenger Reports,* Zool., vol. 17, p. 70, Pl. 8, Fig. 3. 1886.
—— Fulton and Grant, *Proc. Roy. Soc. Victoria,* vol. 19, p. 17. 1906.
Paramicippa spinosa Whitelegge, *Mem. Austr. Mus.* 4, vol. 2, Crust., pt. 1, p. 149. 1900.
—— Stimpson, *Smiths. Miscell. Public.*, vol. 49, p. 14. 1907.
—— Hale, *Crust. S. Austr.*, p. 140. 1927.

Opinions have vacillated concerning the distinctness or otherwise of the variety. Miers, for example, described *P. affinis* as new (1876), and eight years later stated that the British Museum contained specimens of *P. spinosa* from New Zealand, these being presumably the same as those previously described as new. In 1886 he stated that the form *affinis* was distinct, and ranked it as a variety. Our non-committal attitude allows us to include references to the species s.str. as well as to the supposed variety, and does not imply a denial of the distinctness of the latter; it has, for example, been recognized in Australia.

Hutton doubted the occurrence of this species or variety in New Zealand (1882), but it is included in the *Index* under the name *Micippa spinosa* (p. 248). He has no MS. comment. We have seen no specimens, and can only state that both the species and the variety have been recorded from Australia and from New Zealand, but that the New Zealand records are doubtful.

Prionorhynchus edwardsii Jacquinot and Lucas.

Prionorhynchus edwardsii Jacquinot and Lucas, *Voyage au Pole Sud.*, vol. 3, Crust., p. 8, Pl. 1, Fig. 1. 1853.
—— Miers, *Cat. Crust. N.Z.*, p. 11. 1876.
—— Hutton, *Trans. N.Z. Inst.*, vol. 11, p. 340. 1878.
—— Filhol, *Mission de l'Ile Campbell*, p. 367, Pl. 42, Figs. 1-4. 1885.
—— Rathbun, *Proc. U.S. Nat. Mus.*, vol. 15, p. 243. 1892.
—— Hodgson, "Southern Cross," Crust., p. 230. 1902.
—— Chilton, *Subant. Isl. N.Z.*, vol. 2, p. 608. 1909.
—— Chilton, *Rec. Cant. Mus.*, vol. 1, no. 3, p. 290. 1911.
—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 237. 1913.
—— Stephensen, *Dr. Th. Mortensen's Pacific Exped.* 1914-16, 40, p. 292. 1927.

In very small specimens (carapace 30 mm. long) the granulations on the legs are prominent and extend over all parts except the palm and fingers; in adult specimens they are flat and minute.

"This species lives at a depth of 4 to 5 metres (2 to 3 fathoms) and is never met with on the shore or under stones. It collects in large groups of two to three hundred individuals, and such groups may be seen on the sea-bottom, covering a considerable area." (Filhol).

Locality.—Auckland Islands (Jacq. and Lucas; Hodgson; Stensen).
Campbell Island, abundant (Filhol).
Stewart Island (Chilton).
Otago Heads, occasionally in large numbers. (Thomson).
Stewart Island, occasionally in large numbers (W. Traill).

Distribution.—Endemic; chiefly at southern islands.

Eurynolambrus australis Milne-Edwards and Lucas.

Eurynolambrus australis Milne-Edwards and Lucas, *Archiv. du Mus. d'Hist. nat.*, p. 481, Pl. 28, Figs. 14-15. 1841.
—— Filhol, *Mission de l'Ile Campbell,* p. 371, Pl. 43, Figs. 7-9. 1885.
—— Miers, *Cat. Crust. N.Z.* p. 12. 1876.
—— Lenz, Zool., *Jahrb.*, Bd. 14, p. 458. 1901.
—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 237. 1913.

Our specimens agree well with Hutton's MS. note, "Claws purple, inner margins white."

Filhol (l.c., p. 371) proposes a variety *stewarti,* but seems to confess that it is based on individual variations scarcely sufficient to justify the distinction of a variety. His figure is of the supposed variety. The locality quoted is Stewart Island; our only specimen from there is normal, while a specimen from near Oamaru is much punctulated, like the variety.

Locality.—N.Z. (Miers; Austr. and Macleay Museums, Sydney).
Bay of Island (Dana).
Sumner, Chatham Islands (Hutton).
Stewart Island, Cook Strait, Massacre Bay; very abundant on muddy bottoms at a depth of 15 fathoms (Filhol).
Stewart Island (W. Traill).
Chatham Islands (W. Maxwell Young, Miss S. D. Shand).
Cape Maria; near Oamaru, 20 fathoms (Capt. Bollons).
French Pass; Akaroa Heads (Lenz).
Very occasionally met with on the east coast of Otago (Thomson).
Moko Hinau (C. R. Gow).
Kapiti Island (Wanganui Museum).

Distribution.—Endemic.

Type.—Paris Museum.

Cancer novae-zealandiae (Jacquinot and Lucas).

Platycarcinus novae-zealandiae Jacquinot and Lucas, *Voyage au Pole Sud.*, Zool., vol. 3, Crust., p. 34, Pl. 3, Fig. 6. 1853.
Cancer novae-zealandiae Milne-Edwards, *Nouv. Archiv. Mus. Hist. Nat.*, vol. 1, p. 189. 1865.
—— Miers, "Erebus and Terror," Zool., Crust., p. 2, Pl. 1, Fig. 5. 1874.
—— Miers, *Cat. Crust. N.Z.*, p. 14. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 371. 1885.
—— Lenz, Zool., *Jahrb.*, 14, p. 459. 1901.
—— Chilton, *Subant. Isl. N.Z.*, vol. 2, p. 608. 1909.
—— Chilton, *Records Cant. Mus.*, vol. 1, No. 3, p. 291. 1911.
—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 237. 1913.
—— Stephensen, *Dr. Th. Mortensen's Pacific Exped.* 1914-16, 40, p. 293. 1927.

Carapace wide, moderately flattened in the male, much more in the female. Surface covered with little granulations; regions scarcely distinct; antero-lateral margins with ten lobes, which project very slightly beyond their lines of coalescence; each lobe with 2 to 5 crenulations. The posterior lateral margin, which commences immediately behind the tenth lobe, is closely granulous. First lobe small, on upper orbital margin; the latter has no tooth or spine except the point at the inner corner, which is less prominent than the front. Front with three other teeth, of which the median is much smaller and more depressed than the rest. Anterior legs with the wrist very granulous externally, usually with a large tubercle near the margin, and a strong tooth on the inner side; hand granulous above, with two parallel lines, each having three or four tubercles larger than the granulations, and with five granulous lines on the outer side, of which the lower four are well marked. Movable finger granulous above, both fingers strongly denticulate within, black within and at the tips. Ambulatory legs robust and of moderate length. Seventh joint of the abdomen of the male slender and elongate.

"This species is very probably identical with the *C. plebeius* Poeppig, from Chili. The graulated ridges on the claws, and the shape of the teeth on the latero-anterior margin vary much in the specimens in the Museum, from both localities, but A. Milne-Edwards in his monograph above quoted, considers the species distinct." (Miers, 1874). Though we have not seen specimens from Chili, we have verified that the New Zealand form is variable in the respects mentioned by Miers, and also in the distinctness or otherwise of the outer tubercle of the hand. The lobes of the antero-lateral margins are sometimes black.

In order to settle the question of the distinctness or otherwise of the two species specimens of *C. novaezealandiae* were, in 1910, sent to Dr. Calman of the British Museum for comparison with *C. plebeius*. In his reply he drew attention to Miss Rathbun's paper on " The Stalk-eyed Crustacea of Peru and the adjacent coast (Proc. U.S. Nat. Museum, vol. 38, pp. 531-620) in which the original figure of *C. plebeius* is reproduced and added "There is no doubt, from the speci-

mens we have, that the species is perfectly distinct from the New Zealand one. Milne-Edwards in his Famille des Canceriens (*Nouv. Arch. Mus. Hist. Nat.* 1, 1865, p. 190) says 'Cette espèce ressemble beaucoup au *Cancer plebeius* des cotes du Chili. Elle peut cependant s'en distinguer facilement si l'on observe les granulations des pinces et le forms des dents ou lobes qui découpent les bords latéro-antérieures. Chez le *C. novaezealandiae* les neuvième et dixième lobes sont arrondies et peu avancés; au contraire chez le *C. plebeius*, ces lobes prennent la forme de véritables dents, ils sont plus ou moins triangulaires et aigues.'

"This difference in the form of the lateral lobes is," continues Dr. Calman, "well seen in the figure reproduced by Miss Rathbun. There are, however, many other characters distinguishing the two:—the hands are much more elongated in *C. plebeius*, the dorsal surface of the hands is smooth between the ridges, the carapace is less vaulted and more uneven, the median tooth of the front is more prominent, the dorsal roof of the orbit is less swollen between the sutures, etc. Altogether I think the species are very well distinguished."

The dimensions may greatly exceed those hitherto recorded, as shown in the following list:—

Miers 1874	length 57 mm.,	breadth 87 mm.
Miers 1876	„ 48 „	„ 70 „
Filhol	„ 36 „	„ 52 „
Large specimen from Lyttelton	„ 78 „	„ 127 „

Locality.—N.Z. (Miers).
Akaroa (Hombron and Jacquinot).
Lyttelton, Port Levy, Sumner (Hutton).
Cook Strait, Stewart Island; very abundant on muddy bottom at a depth of 5 to 8 fathoms (Filhol).
Auckland Islands (Chilton, Stephensen).
Dunedin (Austr. Mus., Sydney).
Wellington (Macleay Collection).
Stomach of dogfish, Otago (T. Anderton, T.N.Z.I., vol. 38, p. 546).
Extremely abundant in Otago Harbour and along the coast-line, from the exposed sand-beach to 30 fathoms (Thomson).
Auckland Harbour, Akaroa, Kaikoura, Lyttelton Harbour, Sumner, Taylor's Mistake, Timaru; small specimens very common in pools, under stones, and sluggishly sheltering among weeds and Polyzoa in intertidal zone; larger ones chiefly in deeper water or as drift on beaches (E.W.B.).
French Pass (Lenz).
Nukumaru (Wanganui Museum).

Distribution.—Endemic, evidently commoner in the South than in the North Island.

Megametope rotundifrons (Milne-Edwards).

Xantho rotundifrons Milne-Edwards, *Hist. Nat. Crust.*, vol. 1, p. 397. 1834.
Megametope rotundifrons Filhol, *Mission de l'Ile Campbell,* p. 373, Pl. 44, Fig. 3. 1885.
—— McNeil, *Rec. Austral. Mus.*, vol. 15, p. 130. 1926.
—— Hale, *Crust. South Austr.*, p. 157. 1927.

The record of this species is somewhat unsatisfactory, in that Filhol, on whose mention of Cook Strait and Foveaux Strait the record depends, did not list the species under a caption of its own, but merely *en passant* while referring to *Heterozius rotundifrons.* The history of the species has been dealt with by McNeil (1926, p. 130). It has not been recognised by New Zealand collectors.

Locality.—N.Z. (Filhol —?).
Distribution.—Australia.
Type.—Paris Museum.

Heterozius rotundifrons Milne-Edwards

Heterozius rotundifrons Milne-Edwards, *Ann. Soc. Entom. France*, vol. 7, p. 275. 1867.
—— Miers, *Cat. Crust. N.Z.*, p. 15. 1876.
—— Filhol, *Mission de l'Ile Campbell*, p. 372, Pl. 44, Figs. 6-7. 1885.
—— Lenz, *Zool. Jahrb.*, Bd. 14, p. 459. 1901.

Carapace flattened, scarcely grooved, smooth. Antero-lateral margins very long, so that a line joining their posterior angles would divide the carapace into two unequal parts, of which the anterior would be much the larger. They form a regular curve with the front, interrupted only by the orbits, anterior median fissure, and two small lateral fissures; the latter obscurely define two lobes. From the first fissure arises a shallow groove which limits the hepatic region behind, and ends in a deeper pit not far from the margin and parallel to it. A minute antero-lateral fissure sometimes occurs in front of the normal two. The cardiac region is marked laterally by a curved shallow groove, concave outwards. Front of carapace narrow, prominent, and, except for the faint median sulcus, rounded in the middle. Basal joint of the external antennae so small that the latter are scarcely separated from the fossettes of the inner antennae. Under surface of the body and legs covered with very short hairs, especially in the female. Hands equal in the female, right hand enlarged in the male. Unenlarged hands rounded above, and smooth, except for a faint longitudinal groove along the upper outer surface, in a line with the movable finger; on the upper inner surface of the hand, near the wrist, is a small tubercle, variable in size; adjacent to it, the angle of the wrist sometimes makes a small tubercle. Fingers slender, as long as the palm, and nearly straight; each finger bears six to eight teeth, which are distant and separated by much finer denticulations; the fingers cross slightly at the tip. In the right hand of the male, the palm is much swollen, the tubercle is much more distinct, groove very faint; fingers thick, separated at the base, with the larger teeth prominent.

The above description contains some additions to those of Miers and Milne-Edwards.

Filhol states that usually the right arm of the female is more enlarged than the left, whereas a study of about 75 females in our collections has shown that only three had the right arm longer than the left.

In a few of our collections, the males are twice as numerous as the females, but these proportions are more than reversed in most of the collections; of 165 specimens from 14 localities, only 51 are males. Possibly the females are more numerous, but remain secluded while carrying eggs.

Filhol's figure shows four lateral fissures on the carapace. Also the margin of the carapace appears to be continued horizontally to the posterior end, whereas in our specimens the postero-lateral parts of the carapace are excavated to form a recess for the last pair of legs.

In recording the dimensions of his specimens, Lenz appears to have transposed the length and breadth. Measurements of some of our specimens are as follows (millimetres):

	Average female	Average male	Large female	Large male
Length of hand .	11 5	17	14	27 5
Breadth of hand	3	9	4.5	15
Length of carapace .	13	14	17.5	19
Breadth of carapace .	18	20	25.5	25

Locality.—N.Z. (Milne-Edwards, Miers, Macleay collection).
Chatham Islands, Cook Strait (Hutton).
Nelson, Cook Strait (Filhol).
Stewart Island (Filhol, Hutton, W. R. B. Oliver, C.C.).
Robin Hood Bay, Marlborough (G. Bigg-Wither).
Cook Strait, Bay of Islands (G. E. Archey).
Rangitoto (W. R. B. Oliver, G. E. Archey).
Puysegur Point, Stephens Island (T. B. Smith).
French Pass (Lenz).
Russell, Wellington Harbour, Queen Charlotte Sound (C.C.).
Sumner, Kaikoura (E.W.B.).
Wellington Harbour (Wanganui Museum).

Distribution.—New Caledonia.
Type.—Paris Museum.

Leptodius nudipes (Dana).

Chlorodius nudipes Dana, *Proc. Acad. Nat. Sci. Philad.*, p. 79. 1852.
—— Dana, *U.S. Expl. Exped.*, vol. 13, pt. 1, p. 209, Pl. 11, Fig. 12. 1855.

Leptodius nudipes A. Milne-Edwards, *Nouv. Archiv. Mus. Nat. Hist.*, Paris, vol. 9, p. 225, Pl. 7, Fig. 5. 1873.
—— Miers, *Cat. Crust. N.Z.*, p. 17. 1876.
—— Filhol, *Mission de l'Ile Campbell*, p. 374. 1885.
—— Miers, *Challenger Reports*, Zool., vol. 17, p. 137. 1886.
—— Rathbun, *U.S. Fish Commission Bulletin* for 1903, pt. 3, p. 848, Pl. 9, Fig. 3. 1903.
Xantho (*Leptodius*) *nudipes* Alcock, *Journ. Asiatic Soc. Bengal*, vol. 67, p. 121. 1898.
—— Chilton, *Trans. N.Z. Inst.*, vol. 43, p. 555. 1911.
Leptodius nudipes Bouvier, *Bull. Sci. Fr. et Belg.*, vol. 49, fasc. 3, p. 105. 1915.

(Not *Xantho nudipes* Milne-Edwards).

Although Hutton expressed a doubt whether Milne-Edwards' record of this species from New Zealand was correct, he has written the note "Cook Strait" in his copy of Miers' Catalogue, but this may be merely a quotation from Filhol, who says the specimens in the Paris Museum came from Cook Strait.

Locality.—N.Z. (Milne-Edwards).
Cook Strait (Hutton, MS.).

Distribution.—New Caledonia, Sandwich Islands, Kermadec Islands.

Leptodius eudorus Herbst.

Leptodius eudorus Herbst, *Krabben*, vol. 3, Pl. 2, Fig. 3. 1799.
Chlorodius eudorus M. Edwards, *Hist. Nat. Crust.*, vol. 1, p. 402. 1834.
—— White, Dieffenbach's *New Zealand*, vol. 2, p. 265. 1843.
—— Miers, *Cat. Crust. N.Z.*, p. 17. 1876.
—— Filhol, *Mission de l'Ile Campbell*, p. 374. 1885.
—— Miers, *Challenger Reports*, Zool., vol. 17, Crust., p. 137. 1886.
—— Chilton, *Trans. N.Z. Inst.*, vol. 43, p. 555. 1911.

(Not *Xantho eudora* Owen, 1839).

Hutton has questioned the occurrence of such a species in New Zealand. It is congeneric with *Leptodius nudipes* Dana, and must bear the same generic name; but there is some doubt as to what the latter should be. New Zealand authors have used *Chlorodius* for the present species, and Alcock has recommended *Xantho*—which causes trouble with Owen's *Xantho eudora*. Fortunately there is the authority of Miss Rathbun and of Bouvier for the use of *Leptodius*.

The species, after all, may be merely a subspecies of *L. nudipes*, as Filhol considered it to be. At present it can hardly be reckoned to be an authentic member of the New Zealand fauna.

Xantho spinotuberculata Lockington.

Xantho spinotuberculata T. Kirk, *Trans. N.Z. Inst.*, vol. 11, p. 396.
—— Filhol, *Mission de l'Ile Campbell*, p. 379. 1885.

It is not likely that much will be lost by ignoring this record, as has been done in the *Index Faunae N.Z.*

Pilumnus.

The crabs of the genus *Pilumnus* are not common in the littoral zone in New Zealand; they are somewhat solitary in habit, and rendered inconspicuous by their covering of grey hairs and the flocculent matter entangled in the latter. As moreover they are of sluggish and retiring habits, it is not surprising that they are very imperfectly known. The genus as a whole contains a great number of species, differing for the most part in confusingly small details. We have not revised the New Zealand species in this paper, which therefore has the merit of not adding any new species, though one or two are known to us.

Five species have been reported from New Zealand, but only three of the records appear to be valid. *P. vespertilio* is a well-known species, common throughout the Indo-Pacific; it was included in Miers' Catalogue, but placed on Hutton's " black list." Specimens of a species of *Pilumnus* occasionally found in the tangled holdfast of the seaweed *Macrocystis* and in similar places in Lyttelton Harbour were sent to Dr. Calman of the British Museum, who replied that they were identical with specimens from New Zealand in the British Museum labelled *P. vespertilio* by Miers, but that these were certainly not *P. vespertilio* on the evidence of the other specimens so labelled in the British Museum collection and on the evidence of the description given by Alcock, (Jour. Asiatic Soc. Bengal, 67 (2), 1898, p. 192.). The Lyttelton specimens were referred by Calman to de Man, who reported that they appeared to him to belong to *Pilumnus novaezealandiae* Filhol. It is quite as certain that the record of *P. tomentosus* by Miers was also incorrect. Hutton has not named it among the *excludenda,* but has crossed it off from his copy of the Catalogue; and though it is known in great detail from Whitelegge's very full description (Mem. Austr. Mus., 4, vol. 2, p. 149, 1900) it has not been recognised in New Zealand. Filhol did not collect either species, but described two more, *P. spinosus* and *P. novae-zealandiae.* Although Miss Rathbun considers that Filhol has misunderstood *P. tomentosus* (Biol. Results "Endeavour" Exped., 1909—14, p. 119), his two new species are apparently both valid. A further species, *P. maori,* has been described by Borradaile (*Brit Antarct. Exped.* 1910, Zoology, vol. 3, p. 99, Fig. 10) from a single very small male, 6 mm. in length, dredged in 70 fathoms near East Cape during the British Antarctic Expedition of 1910, and his description agrees well with some twelve specimens, representing both sexes, in our collections; they are, however, much larger, up to 21 mm. in length, and were collected at Ponui Island, Ponsonby Reef, and Akaroa.

Pilumnopeus serratifrons (Kinahan).

Ozius serratifrons Kinahan, *Journ. Roy. Soc. Dublin,* vol. 1, p. 113, Pl. 4, Fig. 1. 1856.
Pilumnopeus serratifrons Miers, *Cat. Crust. N.Z.,* p. 20. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 378. 1885.
—— Haswell, *Cat. Crust. Austr.,* p. 70, Pl. 2, Fig. 1. 1882.
—— Miers, Zool. H.M.S. " Alert," p. 228. 1884.

Sphaerozius (?) serratifrons Miers, *Challenger Report*, Zool., vol. 17, p. 144. 1886.

Pilumnopeus serratifrons Fulton and Grant, *Proc. Roy. Soc. Vict.*, vol. 19, pt. 1, p. 18. 1906.

There is only weak evidence that this crab occurs in New Zealand. It was recorded by Miers (1876), and though he again referred (1884) to New Zealand specimens in the British Museum, this does not refute Hutton's view (1882) that it should be excluded from our list.

Ozius truncatus A. Milne-Edwards.

Ozius truncatus A. Milne-Edwards, *Hist. Nat. Crust.*, vol. 1, p. 406, Pl. 16, Fig. 11. 1834.

Xantho deplanatus White, *Juke's Voyage H.M.S. Fly*, p. 337. 1847.

Ozius lobatus Heller, *Reise der Novara*, Zool. Bd. 2, abt. 3, p. 21, Pl. 2, Fig. 4. 1868.

Ozius truncatus Dana, *U.S. Expl. Exped.*, vol. 13, Crust., pt. 1, p. 230, Pl. 13, Fig. 4. 1852.

—— Miers, *Cat. Crust. N.Z.*, p. 21. 1876.

—— Haswell, *Cat. Crust. Austr.*, p. 63. 1882.

—— Filhol, *Mission de l'Ile Campbell*, p. 379. 1885.

—— de Man, *Abh. Senckenb. Natf. Ges.*, 25, p. 628, Pl. 21, Figs. 22, 23. 1902.

—— Stimpson, *Smithsonian Miscell. Coll.*, vol. 49, No. 1717, p. 60. 1907.

—— Hale, *Crust. S. Austr.*, p. 160. 1927.

—— Lenz, *Zool. Jahrb.*, Bd. 14, h. 5, p. 465. 1901.

(Not *Xanthodius lobatus* Milne-Edwards, 1880).

This species was originally recorded by Milne-Edwards from Australasia; Filhol, who had access to the same collections, states that Milne-Edwards' type specimen was from Australia, and we do not know whether there were more specimens from New Zealand; Filhol adds, however, that he himself had collected a specimen in New Zealand which was exactly the same. Dana has recorded the species from the Bay of Islands. According to Miers, specimens from both countries and from Lord Howe Island are in the British Museum, but again it is not clear whether true *O. truncatus* from New Zealand is included. Some and perhaps all of the specimens so named by Miers were those labelled *O. deplanatus* by White, these being included by Miers—with some doubt and certain qualifications of the description—in *O. truncatus*.

Now it is this amended description which most accurately applies to the specimens before us, viz., "the antero-lateral margins are granulous, the anterior tooth very broad and scarcely distinct; the second, obtuse; the third and fourth more acute, but still broad." As this refers to White's specimens only, and the rest of *O. truncatus* as determined by Miers had the "latero-anterior margins short, and divided into four or five wide obtuse lobes," and as our specimens have, for example, no sign of a fifth lobe, we conclude that the specimens before us are what White called *O. deplanatus*. And further, as the only clear statement of the record of *O. truncatus* in New Zealand, apart from *O. deplanatus*, depends on Dana's mention of

the Bay of Islands, we conclude that the commoner species in New Zealand, and possibly the only one, is what White called *O. deplanatus.*

The question therefore is whether *O. deplanatus* is a synonym of *O. truncatus;* and the question is further complicated by the fact that Heller has a species, *O. lobatus,* which appears to agree with the New Zealand specimens, though the localities mentioned by him for *O. lobatus* were Shanghai, Sydney, and Tahiti.

Specimens of the New Zealand species were sent in 1914 by the senior author to Dr. W. T. Calman at the British Museum, who replied:—" The crab you send is undoubtedly the same species as the numerous specimens (including those from New Zealand) determined as *O. truncatus* in our collection. We have none determined as *O. lobatus.* De Man discusses the two species and figures the type-specimens of both in *Abh. Senckenb. Natf. Ges.,* 25, p. 628, Pl. 21, Figs. 22-23, 1902. He thinks they are distinct species, but I should doubt it." We have not seen the work referred to, and are unable at present to decide definitely upon the status of either White's *O. deplanatus* or Heller's *O. lobatus.* Lenz quotes with approval the opinion of Haswell that *O. truncatus* and *O. lobatus* are identical, and we can only repeat the caution (Chilton, *Trans. N.Z. Inst.*, vol. 43, p. 556, 1911) that " a comparison of typical specimens is desirable before the two are combined."

There is thus some doubt as to the correctness of the above synonymy, in which *O. deplanatus* and *O. lobatus* are reduced to synonyms of *O. truncatus;* but it does not seem to have been realised that if they are synonymous with one another but not with *O. truncatus,* the name *deplanatus* has priority over *lobatus.*

Locality.—N.Z. (White, Miers).
Bay of Islands (Dana).
Auckland (Hutton—specimens labelled *O. truncatus* are in the Canterbury Museum).
North part of the South Island (Filhol).
Cuvier Island (Grenfell and Barr).
Portland Island (C. Riesop).
Auckland, Tiri-tiri (*O. lobatus*) (Lenz).
Mokohinau (C. R. Gow).
" Common on the northern shores of New Zealand—from Portland Island northwards. During the ' Hinemoa' trip, 1914-1915, I got it at various places on the east and west coasts—Cuvier Island, Kaipara Harbour, etc." (C.C., MS.).
This species scarcely extends to the South Island.

Distribution (O. lobatus).—Australia, Kermadecs.

Panopeus otagoensis Filhol.

Panopeus otagoensis Filhol, *Mission de l'Ile Campbell,* p. 379, Pl. 40, Fig. 1.

This species is known from a single male specimen collected by Hutton at Port Chalmers and described by Filhol. It would thus appear that the species is endemic, and that the type is in the Paris Museum.

Ruppellioides convexus A. Milne-Edwards.

Ruppellioides convexus A. Milne-Edwards, *Soc. Ent. France,* ser. 4, vol. 7, p. 279. 1867.
—— Filhol, *Mission de l'Ile Campbell,* 1885, p. 381, Pl. 41, Fig. 7.
—— Miers, *Cat. Crust. N.Z.,* p. 23. 1876.

Milne-Edwards has described this species from material collected by Quoy and Gaimard at Massacre Bay; but Hutton has queried its validity, and it does not seem to have been seen again.

Portunus pelagicus (Linnaeus).

Cancer pelagicus Linnaeus, *Syst. Naturae,* ed. 12, p. 1042. 1766.
Neptunus pelagicus Milne-Edwards (part), *Archiv. Mus. Hist. Nat.,* vol. 10, p. 320. 1861.
—— de Haan, *Fauna japonica,* Crust., p. 37, Pls. 9, 10.
—— Miers, *Ann. Mag. Nat. Hist.,* ser. 4, vol. 17, p. 221. 1876.
—— Miers, *Cat. Crust., N.Z.,* p. 25. 1876.
—— Haswell, *Cat. Crust. Austr.,* p. 77. 1882.
—— Miers, Zool. H.M.S. "Alert," p. 229. 1884.
—— Filhol, *Mission de l'Ile Campbell,* p. 381. 1885.
—— Miers, *Challenger Reports,* Zool., vol. 17, p. 173. 1886.
—— Ortmann, *Zool. Jahrb.,* vol. 7, p. 74. 1893.
—— Ortmann, *Zool. Forschungsreisen in Austr.,* Bd. 5, lief. 1, p. 45. 1894.
—— Alcock, *Journ. Asiatic Soc. Bengal,* vol. 67, p. 34. 1898.
—— Whitelegge, *Mem. Austr. Mus.,* 4, vol. 1, Crust., p. 154. 1900.
Portunus pelagicus Fabricius, *Entom. Syst.,* Suppl., p. 367. 1798.
—— Rathbun, *Proc. U.S. Nat. Mus.,* vol. 36, No. 1037, p. 26. 1902.
—— Rathbun, "*Endeavour*" *Sci. Results,* p. 130. 1923.
—— Hale, *Crust, Sth. Austr.,* p. 149, 1927.

The claim of this crab to be a constituent of our fauna depends on the label of a British Museum specimen collected by Sowerby, and has been rejected by Hutton. The crab, however, is "a common species in the Sydney market" (Haswell), so that it is liable to turn up within the northern part of the New Zealand region.

Locality.—N.Z. (Miers).
Not N.Z. ? (Hutton).

Distribution.—Red Sea, Indian Ocean, East Indies, Philippines, China, Japan, east coasts of Australia.

Portunus sayi (Gibbes).

Lupa sayi Gibbes. *Proc. Amer. Assoc.,* p. 178. 1850.
—— Dana, *U.S. Explor. Exped.,* vol. 13, Crust., p. 273, Pl. 16, Fig. 8. 1852.
Neptunus sayi Milne-Edwards, *Archiv. Mus. Hist. Nat.,* vol. 10, p. 317, Pl. 29, Fig. 2. 1861.
—— Miers, *Cat. Crust. N.Z.,* p. 24. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 381. 1885.
—— Miers, *Challenger Reports,* Zool., vol. 17, p. 173. 1886.
Neptunus (*Neptunus*) *sayi* Lenz and Strunck, *Deutsche Sudpolar Exp.,* vol. 15, p. 278. 1914.

One specimen in the British Museum, identified by Miers, is the sole claim of this American species to be included in the New Zealand fauna. Hutton has questioned its occurrence, and it has not been found again.

Portunus pusillus Leach.

Portunus pusillus T. Kirk, *Trans. N.Z. Inst.*, vol. 11, p. 402.
—— Filhol, *Mission de l'Ile Campbell*, p. 381. 1885.
—— Miers, *Challenger Reports*, Zool., vol. 17, p. 200. 1886.

Kirk's record is unsubstantiated, and probably depends on a wrong identification; but species of this genus are liable to stray beyond their usual range.

With regard to the generic name, a strict adherence to the rules of nomenclature would invalidate *Portunus* for this and the next species at least, leaving them and some others without a generic title. Miss Rathbun has discussed the case (*Proc. Biol. Soc. Washington*, vol. 9, pp. 153-167, 1897), and has pointed out that there is a valid name available in *Liocarcinus* Stimpson (*Bull. Mus. Comp. Zool., Harvard*, vol. 11, pp. 145-6, 1869); but most writers have refused to abandon the familiar name, chiefly on the grounds of inconvenience. In a recent study of the British species, Palmer has sought for less indefensible reasons, and having found only equivocal ones has referred the matter to the International Commission for a decision (*Journ. Mar. Biol. Station, Plymouth*, n. s., vol. 14, p. 877, 1927).

Locality.—Cook Strait (Kirk).

Distribution.—Mediterranean, west coasts of Europe and America.

Portunus corrugatus (Pennant).

Cancer corrugatus Pennant, *Brit. Zool.*, 4, p. 5, Pl. 5, Fig. 9.
Portunus corrugatus, Bell, *Brit. Sessile-Eyed Crust.*, p. 94. 1853.
—— Miers, *Challenger Reports*, Zool., vol. 17, Crust., p. 200. 1886.
—— Borradaile, *Brit. Ant. Exp.* 1910, Zool., vol. 3, p. 97, Fig. 9. 1916.

Borradaile records this species from New Zealand, where a small female specimen was dredged in moderately deep water at Station 134.

Locality.—Spirits Bay, 11-20 fathoms (Borradaile).

Distribution.—Very widespread—Australia, Japan, Red Sea, Mediterranean, W. Atlantic.

Nectocarcinus integrifrons (Latreille).

Portunus integrifrons Latreille, *Encycl. Meth.*, 10, p. 192. 1825.
—— Milne-Edwards, *Hist. Nat. Crust.*, vol. 1, p. 445. 1834.
Nectocarcinus melanodactylus Milne-Edwards, *Ann. Sci., Nat.*, ser. 4, vol. 14, p. 220. 1860.
Nectocarcinus integrifons Milne-Edwards, *tom cit.*, p. 220. 1860.
—— Milne-Edwards, *Archiv. Mus. Hist. Nat.*, vol. 10, p. 406, Pl. 38. 1861.
—— Miers, Zool. Erebus and Terror, Crust., p. 2, Pl. 1, Fig. 3 (young). 1874.

Nectocarcinus integrifons Miers, *Cat. Crust. N.Z.* p. 30. 1876.
—— Haswell, *Cat. Crust. Austr.*, p. 81. 1882.
—— Miers, Zool. H.M.S. " Alert," p. 234. 1884.
—— Filhol, *Mission de l'Ile Campbell,* p. 383. 1885.
—— Fulton and Grant, *Proc. Roy. Soc. Vict.*, vol. 19, pt. 1, p. 18. 1906.
—— Rathbun, *Scientific Results " Endeavour,"* p. 130. 1923.
—— Hale, *Crust. South Austr.*, p. 152. 1927.

It is hardly surprising that an Australian swimming-crab should turn up in New Zealand, but it is curious that while three naturalists from abroad have recorded it, and one has stated that it is abundant, the species remains unknown to local naturalists.

Locality.—N.Z. (Milne-Edwards).
Bay of Islands (Miers).
Cook Strait and east coast of South Island, abundant (Filhol).

Distribution.—Australia, Tasmania.

Nectocarcinus antarcticus (Jacq. and Lucas).

Portunus antarcticus Jacq. and Lucas, *Voyage au Pole Sud,* 3, Crust., p. 51, Pl. 5, Fig. 1. 1853.
Nectocarcinus antarcticus A. Milne-Edwards, *Archiv. Mus. Hist. Nat.*, Paris, 10, p. 407. 1861.
—— Miers, *Cat. Crust. N.Z.*, p. 30. 1876.
—— Miers, Zool., " Erebus and Terror," Crust., p. 2, Pl. 1, Fig. 2. 1874.
—— Hutton, *Trans. N.Z. Inst.*, vol. 11, p. 340. 1880.
—— Filhol, *Mission de l'Ile Campbell,* p. 383. 1885.
—— Hodgson, " Southern Cross," Crust., p. 229. 1902.
—— Chilton, *Subant. Isl. N.Z.*, vol. 2, p. 608. 1909.
—— Chilton, *Rec. Cant. Mus.*, vol. 1, No. 3, p. 291. 1911.
—— Rathbun, *Austr. Ant. Exped.*, vol. 5, pt. 2, p. 3. 1918.
—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 237. 1913.
—— Stephensen, *Th. Mortensen's Pacific Exped.*, 1914-16, 40, p. 293. 1927.

In addition to specimens from other localities clearly belonging to this species we have a good series of small crabs, including egg-bearing females whose breadth in some cases is only 12 mm., from Colville Channel and off Little Barrier. We have provisionally referred them to this species, but they may prove to be different and possibly to belong to another genus. The back is more corrugated and the frontal and antero-lateral spines are prominent, especially the pair of post-lateral spines; the latter give rise to a ridge across the carapace resembling the dorsal structure of *Thalamita* and related genera.

Jacquinot and Lucas and others describe the front as 4-toothed, Miers as 6-toothed; the latter reckoning includes the inner orbital spine.

" It is an extremely active and pugnacious species." (Thomson).

Locality.—N.Z., Auckland Islands (Miers, Hodgson).
Auckland Islands (Jacquinot and Lucas, Hutton, Stephensen).
Stewart Island (W. Traill).
East coasts of Stewart and South Islands (Filhol).
Wellington (Hutton, Macleay Collection).
Castlecliff (Wanganui Museum).
"Nora Niven" stations 2, 5, 12, 23, 26, 30, and Chatham Islands (Chilton).
10 miles N.W. of Cape Maria; off Little Barrier, 35 fathoms (C.C.).
Cloudy Bay, 19 fathoms (Captain Bollons).
The Watchman, Hauraki Gulf (G. F. Pirritt).
Stomachs of toad-fish (*Neophrynichthys*), etc. (E.W.B.).
Common in Otago and the adjacent seas (Thomson).

Distribution.—Endemic, including the Auckland and Chatham Islands; commoner in the south.

Thalamita sima Milne-Edwards.

Thalamita sima Milne-Edwards, *Hist. Nat. Crust.*, vol. 1, p. 460. 1834.
—— Milne-Edwards, *Archiv. Must. Hist. Nat. Paris,* vol. 10, p. 359. 1861.
—— Miers, *Cat. Crust. N.Z.*, p. 28. 1876.
—— Haswell, *Cat. Crust. Austr.*, p. 80. 1882.
—— Miers, Zool. H.M.S. "Alert," p. 231. 1884.
—— Filhol, *Mission de l'Ile Campbell,* p. 382. 1885.
—— Miers, *Challenger Reports,* Zool., vol. 17, p. 195. 1886.
—— Ortmann, *Zool. Jahrb.*, vol. 7, p. 84. 1893.
—— Ortmann, *Zool. Forschungsreisen in Austr.*, Bd. 5, lief. 1, p. 46. 1894.
—— Alcock, *Journ. Asiatic Soc. Bengal,* vol. 68, p. 81. 1899.
—— Rathbun, *Proc. U.S. Nat. Mus.*, vol. 36, p. 28. 1902.
—— Rathbun, *U.S. Fish Commiss. Bull.*, pt. 3, p. 873. 1903.
—— Stimpson, *Smiths. Miscell. Coll.*, vol. 49, p. 83, Pl. 11, Fig. 2. 1907.
—— Bouvier, *Bull. Sci. France et Belg.*, vol. 48, fasc. 3, p. 79. 1915.
—— Hale, *Crust. S. Austr.*, p. 151. 1927.

The New Zealand record of this crab depends on the label on a purchased specimen in the British Museum, as related by Miers (1876 and 1884). It is on Hutton's "black list," but members of this family are not to be lightly excluded.

Locality.—N.Z. (Miers).

Distribution.—Indo-Pacific—Red Sea, Java, Japan, China, Australia.

Ovalipes bipustulatus (Milne-Edwards).

Platyonichus bipustulatus Milne-Edwards, *Nouv. Archiv. du Mus. Paris,* 10, p. 413. 1861.
—— Milne-Edwards, *Hist. Nat. Crust.* 1, p. 437, Pl. 17, Figs. 7-10. 1834.

Anisopus trimaculata de Haan, *Fauna japonica,* Crust., decas. 1, p. 13, 1833.

Corystes (*Anisopus*) *punctatus* de Haan, *op. cit.,* p. 44, Pl. 2, Fig. 1. 1835.

Portunus catharus White, Dieffenbach's *New Zealand,* vol. 2, p. 265. 1843.

Platyonichus purpurea Dana, *U.S. Expl. Exped.,* Crust. 1, p. 291, Pl. 18, Fig. 3. 1852.

Platyonichus bipustulatus Miers, Zool. Erebus and Terror, Crust., p. 2, Pl. 1, Fig. 1. 1874.

—— Miers, *Cat. Crust. N.Z.,* p. 32. 1876.

—— Miers, *Proc. Zool. Soc.,* p. 68. 1881.

—— Miers, *Challenger Reports,* Zool., vol. 17, p. 202. 1886.

—— Ortmann, *Zool. Jahrb.,* vol. 7, p. 65. 1893.

—— Ortmann, *Zool. Forschungsreisen in Austr.,* Bd. 5, lief. 1, p. 44. 1894.

Ovalipes bipustulatus Rathbun, *Proc. U.S. Nat. Mus.,* vol. 21, p. 597. 1898.

—— Whitelegge, *Mem. Austr. Mus.,* 4, vol. 2, p. 158. 1900.

Ovalipes trimaculatus Stebbing, *S. Afr. Crust.,* pt. 2, p. 13. 1902.

—— Doflein, *Wiss. Ergeb. Deutschen Tiefsee Exped.* 1898-9, p. 92, Pl. 23, Fig. 6. 1904.

—— Fulton and Grant, *Proc. Roy. Soc. Victoria,* vol. 19, pt. 1, p. 18. 1906.

Ovalipes bipustulatus Rathbun, *Proc. U.S. Nat. Mus.,* vol. 38, p. 577. 1910.

—— Chilton, *Trans. N.Z. Inst.,* vol. 43, p. 554. 1911.

—— Chilton, *Rec. Cant. Mus.,* vol 1, No. 3, p. 292. 1911.

—— Thomson, *Trans. N.Z. Inst.,* vol. 45, p. 237. 1913.

—— Hale, *Crust. S. Austr.,* p. 147. 1927.

The bibliography of this almost cosmopolitan crab is much more extensive than indicated by the above list; fortunately many of the names have not entered into New Zealand literature. Different authors give somewhat different versions of the synonymy, especially of that of the earlier accounts.

The crab is widely distributed around the New Zealand coast; a list of localities is rather a formality, and the authors have taken it in various places in addition to those listed below. It especially prefers a sandy beach in the immediate vicinity of rocks, and is so voracious and determined that it can readily be caught and hauled out of the water by a string baited with mussel. There appears to be discrepancies in the local literature concerning the method of burrowing in the sand (cf. Chilton 1911, p. 554, and Thomson 1913, p. 237); the junior author has seen it burrow tail first, using the fifth legs to root up the sand until only the eyes protrude above the surface.

Locality.—N.Z. (Miers).
Wellington (Hutton, Australian Museum, Macleay Collection).
Chatham Islands (E. R. Waite).
Sumner, Stewart Island (C.C.).

Locality.—Lyttelton, Sumner, Taylor's Mistake, Kaikoura, Timaru, Castlecliff, etc. (E.W.B.).
Ponui Island (W. J. Barr).
Greymouth (R. Helms).
Robin Hood Bay, Marlborough (G. Bigg-Wither).
Ocean Beach, Dunedin; very common in Otago (Thomson).

Distribution.—Indo-Pacific; Indo-Malaysian and Australian seas, Kermadec Islands, Juan Fernandez, Argentine, Chili, Patagonia, Trinidad Channel, Japan, Cape of Good Hope.
In the Atlantic it is represented by *O. ocellatus.*

Ovalipes ocellatus (Herbst).

Platyonichus ocellatus Latreille, *Encycl. Meth.*, vol. 16, p. 152.
—— Milne-Edwards, *Hist. Nat. Crust.*, vol. 1, p. 435.
—— Bell, *British Crust.*, p. 82.
—— Milne-Edwards, *Archiv. Mus. Hist. Nat. Paris,* vol. 10, Pl. 36, Fig. 4. 1861.
—— Hector, *Trans. N.Z. Inst.*, vol. 9, p. 473, Pl. 27, Fig. 1.
—— Filhol, *Mission de l'Ile Campbell,* p. 383. 1885.

A specimen of this crab from Wellington Harbour was identified by Hutton, and the identification verified by Miers from a drawing submitted by Hector. Filhol has since stated that the Paris Museum contains a fine specimen collected at Dunedin by Hutton. It has not otherwise been recorded from these shores, and if correctly identified, may be regarded as an occasional wanderer rather than as established in New Zealand waters.

Locality.—Wellington Harbour (Hutton).
Dunedin (Hutton, fide Filhol).

* *Distribution.*—East America (N.W. Atlantic).

Ommatocarcinus macgillivrayi White.

Ommatocarcinus macgillivrayi White, *Appendix to Stanley's Narrative of H.M.S. Rattlesnake,* vol. 2, p. 393, Pl. 5, Fig. 1. 1852.
—— Milne-Edwards, *Ann. Sci. Nat.*, ser. 3, Zool., vol. 18, p. 163. 1852.
—— Haswell, *Cat. Crust. Austr.*, p. 90. 1882.
—— Filhol, *Mission de l'Ile Campbell,* p. 385. 1885.
—— Miers, *Challenger Reports,* Zool., vol. 17, Crust., p. 247. 1886.
—— Stebbing, *Hist. Recent Crust.*, p. 92. 1893.
—— Chilton, *Rec. Cant. Mus.*, vol. 1, No. 3, p. 292. 1911.
—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 237. 1913.
Ommatocarcinus huttoni Filhol, *l.c.*, p. 384, Pl. 43, Figs. 1, 2. 1885.

The senior author (l.c., p. 292) has already united the names *O. macgillivrayi* and *O. huttoni,* and our present series (12 specimens,

large and small, of both sexes) confirm the conclusion that there is only the one species in New Zealand, though there is still room for doubt. In identifying our species with the Australian *O. macgillivrayi* there is also room for doubt, but not having had Australian specimens for comparison we follow previous authors on this point. The usage of the names has been as follows:—White described *O. macgillivrayi* from a single male collected in Australia; Filhol described *O. huttoni* from a single female collected in New Zealand, and gave reasons for considering the two distinct. Miers had a young male and two small egg-bearing females from New Zealand; being unacquainted with Filhol's work, he did not mention *O. huttoni*, and assigned his specimens to *O. macgillivrayi*, but mentioned differences which, he remarked, "will perhaps be found to be of specific importance." The presumption is that although Miers did not found a new species for his three small specimens, he would readily have referred them to *O. huttoni* if he had known of that species. Our young males are quite similar to his, and young and older females connect these with what Filhol called *O. huttoni;* and we consider that the older males in our collection, and those reported by previous writers, are the same species again. We follow precedent in identifying that species with the Australian *O. macgillivrayi;* although we have had no specimens of the latter, we note the following points in which New Zealand males differ from White's short description:— The chelipeds may be five times as long as the carapace (White states 2½ times); the chelipeds have no sign of a spine at the middle; the wrist is not toothed on the inside; and the inner surface of the hand is very broadly rounded and scarcely ridged.

The dimensions of a large male are as follows:—

Breadth of carapace	17 mm.
Length of carapace	7 mm.
Length of merus	5 mm.
Length of hand	7 mm.
Total length of chelipeds	14 mm.

On the small males, the merus has a spine on each of the two upper edges, and the lower has three or four sharp spines.

Locality.—N.Z. (Filhol).
Queen Charlotte Sound, 10 fathoms (Miers).
10 miles from Cloudy Bay, 19 fathoms; Whale Rock, Bay of Islands, 15 fathoms (Capt. Bollons).
Stewart Island (W. Traill).
"Nora Niven" Station 19 (Chilton).
Bare Island, near C. Kidnappers, 37 fathoms (C.C.).
Off Banks' Peninsula, 20 fathoms (E.W.B.).
"Occasionally taken in trawlers, and found in the stomachs of fishes, from outside Otago Heads." (Thomson).

Distribution.—Australia.

Hemiplax hirtipes (Jacq. and Lucas).

Cleistostoma (*?*) *hirtipes* Jacquinot and Lucas, *Voyage au Pole Sud,* Zool., vol. 3, Crust., p. 69. 1853.
Metaplax hirtipes Heller, *Verhandl, d. k. zool.-bot. Gesellsch., Wien,* vol. 12, p. 251. 1862.
Hemiplax hirtipes Heller, *Voyage der Novara,* Crust., p. 40, Pl. 4, Fig. 3. 1865.
—— Miers, *Cat. Crust. N.Z.,* p. 34. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 385. 1885.
—— Miers, *Challenger Reports,* vol. 17, p. 251. 1886.
—— Chilton, *Subantarctic Isl. N.Z.,* vol. 2, p. 608. 1909.
Macrophthalamus hirtipes Thomson, *Ann. Mag. Nat. Hist.,* ser. 7, vol. 10, p. 462. 1902.
—— Thomson, *Trans. N.Z. Inst.,* vol. 45, p. 237. 1913.

This crab has given rise to much trouble, concerning both its generic position and especially its identity. The confusion is not lessened by the fact that the same specific name was independently chosen for two supposedly different species, which we now find it necessary to unite; assuming that the latter step is correct, the history of the views as to its generic position is briefly as follows:—

Jacquinot and Lucas had only a single much-damaged specimen, and could only suggest with much doubt that it was a *Cleistostoma*; affinities were also recognised with *Macrophthalamus*. Heller, without recognition of the previous work, located it in *Metaplax*, but later founded the genus *Hemiplax* for it. Miers accepted this name, but later suggested that it might be regarded as a subgenus of *Macrophthalamus*. Thomson has definitely located New Zealand specimens in *Macrophthalamus*, though considering them to be different from Heller's species. Etheridge and McCullough have accepted the genus *Hemiplax*, and have added *M. latifrons* Haswell to it. We have retained the name *Hemiplax*.

As regards the specific name, the problem is whether the *Cleistostoma hirtipes* described by Jacquinot and Lucas from Samoa is the same as *Hemiplax hirtipes* described from Auckland by Heller. Although we have not seen the types, or specimens from Samoa, we have united the two, and the result is the new combination *Hemiplax hirtipes* (Jacq. and Lucas). If, however, the two are not identical, our species is *Hemiplax hirtipes* Heller.

The grounds on which Heller's species has hitherto been regarded as distinct consist chiefly of the smallness of the hands of the male, whereas in many specimens the hands are much enlarged. But Heller had only small specimens, and the same is true of Miers (1876) and Hutton (MS. and named specimens), at least as far as is definitely known. We have a large series from a great number of localities, and regard males with small hands as conspecific with large-handed males; the final shape and proportions are acquired, according to this view, at a late stage of development. There seems to be no other distinguishing feature, and both types are present in collections from the same locality. The only doubtful point, which may not carry any weight, is that one large male in our collection has a large hand and a small one, evidently the result of incomplete regeneration; and the small hand does not resemble the hand of females or small males,

but—except in size—the large hand of large males; which might possibly be interpreted to mean that the males with large and with small hands respectively belong to different species. But the course of development during regeneration is a matter on which experimental work is required, and incidentally we commend the problem to naturalists. If, however, the above interpretation be adopted without further evidence, where are the young males of the species with large hands?

There remains the statement by the Hon. G. M. Thomson (1902) that *Macrophthalamus hirtipes* Jacquinot and Lucas "has hitherto been confused with *Hemiplax hirtipes* Heller, a species from which it is quite distinct." He added, and repeated in 1913, that *Macrophthalamus hirtipes* is common in Otago. The two names were included as distinct species in the *Index Faunae N.Z.*, a view with which we disagree. We do so the more readily because in 1917 Mr. Thomson sent some specimens from Portobello to the senior author, and stated: "I am half inclined to think that this species [*Hemiplax hirtipes*] is only the young stage of *Macrophthalamus hirtipes*. . . . . I have one crab labelled *Macrophthalamus hirtipes*, but it seems only a large form of those I have posted you." We have interpreted this as a retraction of the former view, and acquiesce therein.

In three of our largest males, including a pair from Akaroa, the hands are more elongated than is usual in large males, with longer and thinner fingers; and the upper edge of the movable finger makes a noticeably more acute angle with the upper edge of the palm. The difference is sufficient to distinguish a new species if it is found to be constant in a good series. The Akaroa specimens were taken among rocks on a mud-flat near high-water mark by the junior author in 1921; they were almost white in colour, and had brilliant reddish-brown spots which showed up much more conspicuously than those of the usual dark-coloured specimens, and might well be compared with those of the shrimp *Leander affinis*. Such colour-differences may perhaps be the result of recent ecdysis.

Locality.—Auckland Harbour (Heller).
New Zealand, Queen Charlotte Sound (Miers).
North, South, Stewart, and Campbell Islands (Filhol).
Sumner, Dunedin (Hutton, MSS.).
Ponui Island, Hauraki Gulf (G. F. Pirritt).
Dunedin (Austr. Museum).
Wellington (Macleay Collection, Sydney).
Okarito Lagoon (C. E. Foweraker).
Stewart Island, Heathcote Estuary, Tauranga; mud flats and *Zostera* beds between tides (W. R. B. Oliver).
"Very common on sand-banks in Otago Harbour and shallow bays along the coast. It is an active and most aggressive species." (Thomson).
Otago Harbour (G. R. Marriner, etc).
Heathcote Estuary, Kaikoura, etc., on mud flats and *Zostera* beds, with *Hemigrapsus crenulatus*, but not extending as far altitudinally. (C.C. and E.W.B.).

Distribution.—Endemic.

Uca huttoni (Filhol).

Gelassimus huttoni Filhol, *Mission de l'Ile Campbell,* p. 386, Pl. 45, Figs. 1-3, 8-10. 1885.

The familiar and long-used name *Gelasimus* must be replaced, as various authors have regretfully acknowledged, by Leach's earlier name *Uca,* of which it has proved to be a simple synonym (see Rathbun, *Proc. Biol. Soc. Washington,* vol. 11, p. 154, 1897; Ortmann. *Zool. Jahrb.,* vol. 10, pp. 335 and 346, 1897; Stebbing, *Marine Investig. in S. Afr.,* vol. 4, p. 39, 1905).

The whole genus requires revision, as demanded by Ortmann (l.c., p. 354) and Bouvier (*Bull. Sci. Fr. et Belg.,* vol. 48, fasc. 3, p. 123, 1915). Bouvier, for example, considers most of the characters used in determining the various species to be inadequate, especially those of the male hand, which are variable and do not take the female into account. Milne-Edwards has made use of two reliable characters, the relative width of the front and the granulous lines of the upper orbital edge, forming a supra-orbital space; Bouvier also draws attention to the outer orbital channel formed by the angle of the carapace and the lower orbital margin. More recently, Stebbing has characterized the genus in *Ann. Durban Mus.,* vol. 2, p. 15, 1917.

The validity of the two New Zealand species is not beyond doubt. If the desired revision of *Uca* shows a new genus to be necessary, Filhol's misspelling cannot be taken as a new name.

Locality.—Near Otago Harbour (Filhol; collected by Hutton).
Distribution.—Endemic.
Type.—Paris Museum.

Uca thomsoni (Kirk).

Gelasimus thomsoni Kirk, *Trans. N.Z. Inst.,* vol. 13, p. 236.
—— Filhol, *Mission de l'Ile Campbell,* p. 387. 1885.
—— Miers, *Challenger Reports,* Zool., vol. 17, p. 241. 1886.

Locality.—Wellington (Kirk).—Filhol remarks, without any apparent grounds, that it appears to be common enough; but if so, it would no doubt have become familiar to local naturalists.
Distribution.—Endemic.

Heloecius cordiformis (Milne-Edwards).

Gelasimus cordiformis Milne-Edwards, *Hist. Nat. Crust.,* vol. 2, p. 53. 1837.
Heloecius cordiformis Dana, *Proc. Acad. Nat. Sci. Philad.,* vol. 5, p. 248. 1851.
Heloecius inornatus Dana, *l.c.,* p. 248 1851.
Heloecius cordiformis Dana *U.S. Explor. Exped.,* vol. 13, Crust. 1, p. 320, Pl. 19, Fig. 6. 1852.
Heloecius inornatus Dana, *l.c.,* p. 321, Pl. 19, Fig. 7. 1852.
Heloecius areolatus Heller, *Verhandl. d.k.k. Zool.-Bot. Gesellsch. in Wien,* Bd. 12, p. 519. 1862.
Heloecius signatus Hess, *Archiv. f. Nat.,* Bd. 31, p. 145. 1865.

Heloecius cordiformis Heller, *Reise der Novara,* Crust., p. 39. 1865.
—— Miers, *Cat. Crust. N.Z.,* p. 35. 1876.
—— Haswell, *Cat. Crust. Austr.,* p. 91. 1882.
—— Filhol, *Mission de l'Ile Campbell,* p. 387. 1885.
—— Fulton and Grant, *Proc. Roy. Soc. Victoria,* vol. 19, p. 18. 1906.

We have not given the later synonymy of this crab, which probably does not occur in New Zealand. The record is one of those depending on Miers, and has been questioned by Hutton and struck off in his MS. We have seen nothing like it in collections of New Zealand Crustacea.

Locality.—N.Z. (Miers).
Not N.Z. ? (Hutton).
Distribution.—Australia, Tasmania.

Epigrapsus politus Heller.

Epigrapsus politus Heller, *Verh. zool.-bot. Ges. Wien,* p. 522. 1862.
Nectograpsus politus Heller, *Voyage der Novara,* Crust., p. 17. 1865.
Epigrapsus politus Kingsley, *Proc. Acad. Philadelphia,* p. 192. 1880.
—— Miers, *Challenger Reports,* Zool., vol. 17, Crust., p. 266. 1886.
—— Ortmann, *Zool. Jahrb.,* vol. 7, Syst., p. 703. 1894.
—— Alcock, *Journ. Asiat. Soc. Bengal,* vol. 69, p. 443. 1900.
—— Lenz, *Zool. Jahrb.,* vol. 14, h. 5, p. 471. 1901.

This species is recorded from New Zealand by Lenz; we have seen no specimens.

Locality.—French Pass (Lenz).

Pachygrapsus transversus Gibbes.

Pachygrapsus transversus Gibbes, *Proc. Amer. Assoc. Adv. Sci.,* vol. 3, p. 181. 1850.
—— Miers, *Challenger Reports,* vol. 17, Crust., p. 259. 1886.
—— Lenz and Strunck, *Deutsche Sudpolar Exped.,* vol. 15, p. 284. 1914.

The last-named authors include New Zealand in their statement of the distribution of this crab, but the reference requires verification. The species is widely distributed in the warmer seas, especially the Atlantic, and is reported from Australia and Tahiti.

Grapsus grapsus (Linnaeus).

Cancer grapsus Linnaeus, *Syst. Naturae,* ed. 12, p. 1048. 1766.
Grapsus pictus Miers, *Cat. Crust. N.Z.,* p. 36. 1876.
Grapsus pictus Filhol, *Mission de l'Ile Campbell,* p. 387. 1885.
Grapsus maculatus Whitelegge, *Mem. Austr. Mus.,* 3, 2, p. 139. 1897.
Grapsus grapsus Borradaile, *Proc. Zool. Soc.,* p. 592. 1900.
—— Rathbun, *Proc. Acad. Sci. Washington,* vol. 4, p. 278. 1902.
—— Rathbun, *Proc. U.S. Nat. Mus.,* vol. 38, pp. 547, 588. 1910.
—— Lenz and Strunck, *Deutsche Sudpolar Exped.,* Bd. 15, h. 3, p. 183. 1914.
—— Rathbun, *U.S. Nat. Mus. Bulletin* No. 97, p. 227, Fig. 135. 1917.

Although this crab has an enormous distribution, and may very well occur in New Zealand, it is not typically a South West Pacific species. The records are not entirely convincing, and Hutton has proposed to exclude the species from the list; but it is included in the *Index*. There is a specimen from Kapiti Island in the Wanganui Museum labelled *Grapsus pictus,* but it is *Leptograpsus variegatus.*

Locality.—N.Z. (Miers).
Auckland Harbour (Filhol).

Distribution.—Tropical Indo-Pacific and Atlantic regions, abundant; the distribution is quite circumtropical (Ortmann).

Leptograpsus variegatus (Fabricius).

Cancer variegatus Fabricius, *Ent. Syst.,* vol. 2, p. 450. 1793. Suppl., p. 343, No. 30.
Grapsus variegatus Latreille, *Hist. Nat., Crust.,* vol. 6, p. 71. 1803.
—— Nicolet, in Gay's *Hist. de Chili,* vol. 3, p. 167. 1849.
—— Guerin, *Icon. du Regne Animal, Crust.,* Pl. 6, Fig. 1.
Grapsus personatus Lamarck, *Hist. Anim. sans Vert.,* vol. 5, p. 249. 1818.
—— Latreille, *Encycl. Meth.,* vol. 10, p. 147.
Grapsus strigilatus White, in Gray's *Zool. Miscell.,* p. 78. 1842.
—— Dieffenbach, *New Zealand,* vol. 2, p. 265. 1843.
Grapsus planifrons Dana, *Proc. Acad. Nat. Sci.,* Philad., p. 249. 1851.
—— Dana, *U.S. Expl. Exped.,* vol. 13, Crust., pt. 1, p. 338. 1852; and Atlas, Pl. 21, Figs. 3a-3c. 1855.
—— Cunningham, *Trans. Linn. Soc.,* Zool., vol. 27, p. 492. 1871.
Grapsus variegatus Milne-Edwards, *Hist. Nat. Crust.,* vol. 2, p. 87. 1837.
—— Haswell, *Cat. Crust. Austr.,* p. 97. 1882.
—— Whitelegge, *Mem. Austr. Mus.,* vol. 2, p. 160. 1900.
—— Miers, *Cat. Crust. N.Z.,* p. 36. 1876.
Leptograpsus variegatus Filhol, *Mission de l'Ile Campbell,* p. 388. 1885.
—— Miers, *Challenger Reports,* Zool., vol. 17, p. 257. 1886.
—— Fulton and Grant, *Proc. Roy. Soc. Vict.,* vol. 19, pt. 1, p. 19. 1906.
—— Rathbun, *Proc. U.S. Nat. Mus.,* vol. 38, No. 1766, pp. 547, 588, Pl. 45, Fig. 2. 1910.
—— Chilton, *Trans. N.Z. Inst.,* vol. 43, p. 560. 1911.
Grapsus (Leptograpsus) variegatus Borradaile, *Brit. Antarct. Exp.* 1910. Zool., vol. 3, p. 101. 1916.
Leptograpsus variegatus Rathbun, *U.S. Nat. Mus., Bull.* 97, p. 234, Pl. 56. 1917.
—— Hale, *Crust. S. Austr.,* p. 180. 1927.

Miss Rathbun (l.c., 1910, p. 234) also quotes as synonyms the following names proposed by Milne-Edwards: *Leptograpsus ansoni, L. gayi, L. verreauxi.* The variability and the wide distribution of this crab account for the extensive bibliography.

A large male in our collections has the following dimensions:—

Length of carapace	......	......	58 mm.
Breadth of carapace	. ..	. ..	68 mm.
Length of arm	......	......	92 mm.
Length of hand	. ..	......	51 mm.
Breadth of hand	.....	......	29 mm.

Locality.—N.Z. (Milne-Edwards, Filhol).
Bay of Islands (Borradaile).
Cuvier Island (Grenfell and Barr, G. E. Archey).
Bay of Islands, North coast of Mahia Peninsula, Slipper Island (G. E. Archey).
Portland Island, Hawke's Bay (C. Riesop).
Cape Maria van Dieman (T. B. Smith).
Eastern Chicken Island, Auckland (C.C.).
Kapiti Island (Wanganui Museum).
Castlecliff (E.W.B.).
Common on shores of the North Island, one of the most active of our shore crabs.

Distribution.—Kermadec Islands (Hutton, Oliver), Australia, Norfolk Island, Marianne Islands, Shanghai, Chili, Peru, St. Ambrose Islands, Juan Fernandez, Pernambuco, etc.

Hemigrapsus sexdentatus (Milne-Edwards).

Cyclograpsus sexdentatus Milne-Edwards, *Hist. Nat. Crust.*, vol. 2, p. 79. 1837.
—— White, Dieffenbach's *New Zealand*, vol. 2, p. 266. 1843.
Hemigrapsus sexdentatus Dana, *U.S. Explor. Exped.*, Crust., 1, p. 348, Pl. 22, Fig. 2. 1852.
—— Milne-Edwards, *Ann. Sci. Nat.*, ser. 3, vol. 20, p. 192. 1853.
—— Miers, *Cat. Crust. N.Z.*, p. 37. 1876.
—— Kingsley, *Proc. Acad. Nat. Sci., Philad.*, p. 207. 1880.
—— Filhol, *Mission de l'Ile Campbell*, p. 388. 1885.
Brachynotus edwardsii Hilgendorf, *Sitz. Gesellsch. Freunde zu Berlin*, p. 68. 1882.
—— Miers, *Challenger Reports*, Zool., vol. 17, Crust., p. 264. 1886.
Heterograpsus sexdentatus Haswell, *Cat. Crust. Austr.*, p. 100. 1882.
—— Lenz, *Zool. Jahrb.*, vol. 14, p. 472. 1901.
—— Thomson, *Trans. N.Z. Inst.*, vol. 38, p. 546. 1906.
—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 237. 1913.

Filhol has described the way in which the colour spreads as growth proceeds. In addition to these differences due to age, there is considerable variation in the colouring, and specimens may be classified roughly as light or dark. The lighter ones have either a grey or a cream-coloured background with markings of light or dark chestnut-red; those of the other series are marked with a dark purple, showing a violet blush, this colour being sometimes intensified on the carapace to a purplish black. In the darker series, the legs are usually transversely banded with broad areas of grey, chiefly—though not exclusively—around the joints. In large specimens the colour may be

extended over the whole carapace, but usually the front half is more deeply pigmented than the posterior; the merus and upper surface of the hand are of the same rich colour as the adjacent parts of the carapace.

The edge of the carapace is raised into a low ridge, which is lightly granulated all round, except along the posterior edge. The carapace is faintly granulated, especially antero-laterally; the hands are microscopically granulated; the subhepatic region is shortly pubescent; the last joint of each walking-leg has two grooves and the penultimate one groove on each surface. This sculpture is not prominent, and the crab is remarkably smooth all over.

The palm is much enlarged in the male. The fingers are comparatively thin, especially the movable one, which is also longer and slightly curved. The teeth are regular, decreasing in size towards the tip, low and flatly rounded. The wide gape at the base of the fingers is mostly filled by a large membraneous pad. The fingers are sharply pointed, and tipped with brown. In the hand of the female, a faint ridge runs along the palm along the outer surface to the tip of the fixed finger, as for example in *Leptograpsus.*

The female abdomen is very large, circular, last segment rounded-trigonous; eggs extremely numerous, 0.5 mm. in diameter.

The order of size for the four pairs of walking-legs is:—2nd, 3rd, 1st, 4th. The male arm is longer than any, the female equal to the fifth pair.

This species, though found everywhere, is less numerous than some of the gregarious species, and is far from being the most abundant species of Crustacea, as Filhol claimed. It may be said to be the most conspicuous crab among intertidal rocks.

As indicated in the following measurements, the relative width of the carapace is variable:—

Length of carapace	(female)	......	38 mm.	(male)	47	mm.
Breadth of carapace	„	....	44 „	„	57	„
Length of arm	„	...	42 „	„	90	„
Length of hand	„	......	22 „	„	60	„
Breadth of hand	„	.....	11 „	„	31	„

As regards the distribution, a letter from the late A. R. McCulloch, of the Australian Museum, states: "This species appears to have been first recorded from Australia by Haswell, who included New South Wales and Victoria in its habitat, though he placed a ? after each. Four specimens are in the Australian Museum labelled "*Heterograpsus sexdentatus,* New South Wales ?" which are doubtless some of those on which the records are based, but they are incorrectly identified, being *Chasmagnathus laevis,* to which *H. sexdentatus* bears some resemblance.

"No Victorian specimens are included in the collections of either the Australian Museum or the Macleay Museum, nor was it obtained by the late Mr. F. E. Grant, who collected in many parts of Port Phillip; the species was also omitted from the Census of Victorian Decapod Crustacea by Fulton and Grant. The records of *H. sexdentatus* from Australia may therefore, I think, be regarded as incorrect."

Locality.—N.Z. (Milne-Edwards; Macleay and Austr. Museums, Sydney).
Auckland Harbour to Stewart Island, abundant; not at Campbell Island (Filhol).
Rangitoto, rocks and mud (W. R. B. Oliver, T.N.Z.I. 54, 542).
Portland Island (C. Riesop, G. E. Archey).
Bay of Islands (Dana, G. E. Archey).
Puysegur Point (J. Pottinger, T. B. Smith).
Cape Campbell (G. F. Pirritt).
Wellington (Hutton).
French Pass (Lenz).
Robin Hood Bay, Marlborough (G. Bigg-Wither).
Otago Harbour (G. R. Marriner).
Ponui Island (W. J. Barr).
Auckland (H. Suter).
Stewart Island (A. W. Parrott).
"An extremely common shore-crab, occurring between tide marks, usually under stones (Otago)." (Thomson).
Waitangi, Onehunga, Lyttelton, Heathcote, Akaroa, Port Chalmers, etc. (C.C.).
Auckland; Lyttelton, Sumner, Governor's Bay, Ohahoa Bay, etc.—all round Banks' Peninsula; Kaikoura; intertidal pools, among loose rock, and especially under stones on sandy beaches, often with *H. crenulatus* (E.W.B.).

Distribution.—Endemic.

Hemigrapsus crenulatus (Milne-Edwards).

Grapsus crenulatus Guerin, *Voyage de la Coquille,* Crust., vol. 1, pt. 2, p. 15.
Cyclograpsus crenulatus, Milne-Edwards, *Hist. Nat. Crust.,* vol. 2, p. 80. 1837.
Hemigrapsus crenulatus Dana, *U.S. Explor. Exped.,* vol. 13, Crust., pt. 1, p. 349. 1852; and Atlas, Pl. 22, Fig. 3. 1855.
Heterograpsus crenulatus Milne-Edwards, *Ann. Sci. Nat.,* ser. 3, vol. 20, p. 193. 1853.
Heterograpsus barbimanus Heller, *Voyage der Novara,* Crust., p. 53, Pl. 4, Fig. 5. 1865.
Heterograpsus crenulatus Miers, *Cat. Crust. N.Z.,* p. 38. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 389. 1885.
—— Thomson, *Trans. N.Z. Inst.,* vol. 45, p. 238. 1913.
Heterograpsus sanguineus Lenz, *Zool. Jahrb.,* Suppl., vol. 5, p. 765. 1902. (Not of Milne-Edwards).
Hemigrapsus crenulatus Rathbun, *Proc. U.S. Nat. Mus.,* vol. 38, No. 1766, pp. 589, 618. 1910.
—— Rathbun, *U.S. Nat. Mus., Bulletin* No. 97, p. 266, Pl. 68. 1917.

This species is distinguished from *H. sexdentatus* by the smaller size, the hairs on the legs, the "barbimanus" condition of the hand of the male, etc. It is much less handsome, and the colours much

duller. It is commonly of an ochreous shade, with reddish-brown spots on the upper surface of the carapace and limbs. Usually the spots are prominent and almost continuous, especially on the carapace; they are then of a deeper shade, varying from red and brown to dark purple, and such specimens have large reddish spots across the top of the hand and the movable finger, and sometimes also the movable finger. The outer surface of the hands is a deep yellowish cream, and the hairs on the legs are coloured a very pale raw umber.

The orbits and lateral teeth vary somewhat in shape. The back is more rounded in the female, the gastric region especially being raised. There is no doubt that Miers was correct in uniting Heller's *H. barbimanus* with this species. The males are much larger than the females, and have enlarged equal hands. Specimens from *Zostera* beds at Akaroa have filamentous algae (*Enteromorpha* ?) on the legs; as in the masking crabs, it is the pilose regions which are affected by the algae. The line on the hand, referred to in the case of *H. sexdentatus,* is present, and more prominent; it is granulated, and sometimes accompanied by rows of punctulations along the fixed finger.

Differences from *H. sexdentatus* have already been noted; the species may also be distinguished from the superficially similar crabs *Hemiplax hirtipes* and *Helice crassa* (which are also mud-burrowers, and are correspondingly coloured), by the shape of the orbits, which are short and rounded, and not continued to the side of the carapace, as in the species named. The three lateral teeth at once distinguish it from *Planes minutus* and from *Cyclograpsus lavauxi.*

The dimensions of the largest male and of the largest female in our collections are as follows:—

Length of carapace	(male)	27 mm.	(female)	22 mm.
Breadth of carapace	„	32 „	„	25 „
Length of arm	„	42 „	„	23 „
Length of hand	„	24 „	„	11 „
Breadth of hand	„	12 „	„	5.5 mm

The habits of this crab require more detailed study. In the Heathcote Estuary, for example, it burrows in the mud flats, and also along clay banks; at Kaikoura it is common under fragments of rock, where the substratum is too stiff for the crab to be able to burrow; at Sumner, large specimens occur with *H. sexdentatus* under rocks on a sandy beach; at Taylor's Mistake it occurs in rock pools on a reef where there is no sand or mud and no opportunity of burrowing; at Kairaki Beach, at the mouth of the Waimakariri River, it burrows in stiff sand well above high-water mark. In the latter case it is half a mile from the sea, and some hundreds of yards from the river; and the burrows do not extend down to the level of the water. It is interesting to note that such diverse habits should be exhibited by a single species.

The distribution of this species suggests a link with South America; but according to Ortmann it is also closely related to *H. erythraeus* (Kossmann) from the Red Sea.

Locality.—N.Z. (Miers; Macleay Collection).
Bay of Islands (Dana).
Very abundant on all coasts, including Setwart Island (Filhol).
Under stones between tidemarks, but not very common (Otago). (Thomson).
Sumner (Hutton).
Heathcote Estuary (W. R. B. Oliver, etc.).
Auckland Harbour (H. Suter, W. R. B. Oliver)).
Ponui Island (W. J. Barr).
Port Chalmers (C.C.) and Dunedin (Thomson); identified by Rathbun (1917).
Okarito, Westland (C. E. Foweraker).
Puysegur Point (T. B. Smith).
Otago Harbour (G. Marriner).
Stewart Island (A. W. Parrott).
Lyttelton, Heathcote, Akaroa, Port Chalmers, Waitangi Beach, Onehunga, Hokianga (mangrove swamp at Rawene) (C.C.).
Auckland Harbour, Castlecliff, Akaroa, Kaikoura, Banks' Peninsula, Kairaki, etc. (E.W.B.).

Distribution.—Chili, west coast of Patagonia.

Hemigrapsus maculatus (Milne-Edwards).

Heterograpsus maculatus Milne-Edwards, *Ann. Sci. Nat.*, ser. 3, vol. 20, p. 193. 1853.
—— Miers, *Cat. Crust. N.Z.*, p. 39. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 389. 1885.
—— Haswell, *Cat. Crust. Austr.*, p. 101. 1882.

The occurrence of this species in New Zealand is very doubtful. We cannot separate the crabs which we have called *H. sexdentatus* into two species, though two main types of coloration have been described above. The S-shaped line of small pits, separating the epi- and meso-branchial lobes, may be made out, but they are not distinct, as Milne-Edwards states to be the case in *H. maculatus.*

The species is excluded from our fauna by Hutton in his earlier critical list; it is queried but not struck out in his manuscript, and retained in the *Index Faunae N.Z.*, no doubt on Filhol's authority. There are specimens labelled *H. maculatus* in the Macleay Museum, and we have seen nothing like these in any collections of New Zealand Crustacea. Filhol, however, has distinguished the species from *H. sexdentatus,* and has stated that it occurs from Auckland to Foveaux Straits—that is, it is coextensive with the other two species As for the distribution, Polynesia has been mentioned, but has been queried by Haswell.

Planes minutus (Linnaeus).

Cancer minutus Linnaeus, *Syst. Nat.*, Ed. 10, p. 1048. 1766.
Planes minutus Dana, *U.S. Explor., Exped.*, vol. 13, pt. 1, p. 346. 1852.
—— Miers, *Cat. Crust. N.Z.*, p. 39. 1876.

—— Haswell, *Cat. Crust. Austr.*, p. 99. 1882.
—— Filhol, *Mission de l'Ile Campbell*, p. 390. 1885.
—— Fulton and Grant, *Proc. Roy. Soc. Vict.*, vol. 19, pt. 1, p. 19. 1906.
—— Hale, *Crust. S. Austr.*, p. 181. 1927.

In New Zealand, apart from a doubtful record by Miers, only one specimen has yet been found. It would be extraordinary if the species did not turn up in our waters, even if only occasionally, for it occurs in all seas, especially the Atlantic, clinging to floating objects, such as seaweed, wood, cuttle-fish pens, etc.; on account of its abundance in the *Sargassum* areas it is commonly known as the "gulfweed crab."

Locality.—N.Z. (Miers).
Moko Hinau; a single specimen, washed ashore on a piece of pumice (C. R. Gow).

Distribution.—Throughout tropical and temperate seas.

Cyclograpsus whitei Milne-Edwards.

Cyclograpsus whitei Milne-Edwards, *Ann. Sci. Nat.*, vol. 20, p. 197. 1853.
—— Filhol, *Mission de l'Ile Campbell*, p. 391. 1885.
Cyclograpsus lavauxi (part) Miers, *Cat. Crust. N.Z.*, p. 41. 1876.
—— (part) Haswell, *Cat. Crust. Austr.*, p. 104. 1882.
—— Chilton, *Trans. N.Z. Inst.*, vol. 43, p. 560. 1911 (not of Milne-Edwards).

This species was very briefly characterized by Milne-Edwards, and disallowed by Miers, who (without seeing specimens) suggested that it was only a variety of *C. lavauxi*. Filhol has admitted the validity of the species by stating that specimens are in the Paris Museum, for he had access to the collections there; but he has shown such deference to the determinations of Milne-Edwards that this is hardly an additional argument in favour of the validity of the species. It is therefore satisfactory to be able to decide quite definitely upon this point, from a study of our own specimens.

C. whitei is a valid species, and the distinctive characters may be conveniently stated in the form of a comparison with the commoner species.

	C. lavauxi.	*C. whitei.*
Regions	Regions defined; front with longitudinal furrow.	Regions not defined; carapace quite smooth except for faint transverse groove in gastric region.
Front	Strongly depressed	Still more depressed; at right angles to carapace.
Carapace	Length 16 mm., breadth 21 mm., ratio 1:1.3 (somewhat variable). Sometimes broader in front than posteriorly, especially in female, but also variable.	Length 18.5 mm., breadth 22 mm., ratio 1:1.2; slightly narrower in front than posteriorly.
Edge of carapace	Finely granulated.	Smooth.

	C. lavauxi.	*C. whitei.*
Orbits	Small but well incised; outer corner raised to a point	Very small; not forming a raised point at the outer corner; eyes very small.
Third joint of external maxillipeds	Subquadrate; length scarcely exceeding breadth; distal end truncate.	Elongate, length nearly $1\frac{1}{2}$ times breadth; distal end distinctly produced on inner side.
Legs	Slender, compressed.	Robust, very slightly compressed.
Tarsi	Long, slender, with six lines of short and very dark hairs running whole length of tarsus.	Short, thick, with hairs only at the tip, but with punctulated lines through the whole length.

Of these characters, those relating to the orbits, maxillipeds, and tarsi are the most distinctive. There are other differences besides the above; thus in the ambulatory legs, the longitudinal ridge on the front and hinder surfaces of the last three joints are less distinct than in the case of *C. lavauxi;* and the same applies to the granulated ridge on the upper edge of the merus of the same limbs. The penultimate joint of the male abdomen is not as swollen as in *C. lavauxi.* The arm of the female has a few long hairs on the anterior edge of the carpus and merus. The dimensions of the tarsi may be indicated from those of the last pair of legs; in *C. whitei,* the length of the tarsus is equal to the breadth of the merus, but in *C. lavauxi* the ratio is $1\frac{1}{2}$ (Filhol's figure is inaccurate in this respect).

The fingers of the hand of the female leave only a small gap when closed; they are regularly and prominently denticulate. The hands of the male are larger, and the fingers leave a wide gap at the base; they are sometimes denticulated as in the female (3 of our specimens), but usually the teeth are obsolete (4) or absent (5).

Neither species is "entirely destitute of hairs," as Miers states. There are short but distinct hairs on the edges of the abdomen and sternum, especially in the female, on the maxillipeds (densely at the base), and over the whole pterygostomial and subhepatic regions.

Locality.—N.Z. (Miers).

Our New Zealand specimens were placed in a jar containing *C. lavauxi* before it was noticed that the two species were distinct, so that the locality or localities are not known; but from MSS. notes we infer that our specimens came from one of the last five localities quoted under *C. lavauxi.*

Distribution.—Kermadecs (Chilton, l c.).

Cyclograpsus lavauxi Milne-Edwards.

Cyclograpsus andouinii Dana, *U.S. Expl. Exped.*, vol. 13, Crust., pt. 1, p. 359, Pl. 23, Fig. 2. 1852. (Not of Milne-Edwards).
Cyclograpsus lavauxi Milne-Edwards, *Ann. Sci. Nat.*, vol. 20, p. 197. 1853
Cyclograpsus laevis Hess, *Archiv. für Naturg.*, Bd. 31, p. 152. 1865.
Cyclograpsus lavauxi Miers (part), *Cat. Crust. N.Z.*, p. 41. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 390, Pl. 41, Figs. 4-6. 1885.

Cyclograpsus punctatus Ortmann (part, not of Milne-Edwards), *Zool. Jahrb.*, vol. 7, p. 729. 1894.
—— Ortmann (part), *Zool. Forschungsreisen in Austr.*, vol. 5, p. 57. 1894.
Cyclograpsus lavauxi Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 238. 1913.
—— Lenz and Strunck, *Deutsche Südpolar Exped.*, vol. 15, p. 283. 1914.

The diameter of the eggs is only 0.2 mm. A pair of specimens of this crab were taken *in copula* on Nov. 28, 1927, beneath a pile of intertidal rocks near Godley Heads. They were not in the water, and their presence was first detected by clicking sounds made by rapid movements of the mouthparts, almost like distant artillery. When unearthed, they were found to be "frothing at the mouth," as many Grapsoid crabs do when imprisoned in a bottle.

Filhol remarks that his specimens from Stewart Island appear to be smaller than those from Cook Strait and Auckland. Some details concerning the species have been given above under *C. whitei.*

Ortmann (l.c., both references) has quoted *C. punctatus* Milne-Edwards from New Zealand. This is not a new record, as he identifies *C. lavauxi* Milne-Edwards and *C. audouini* Milne-Edwards with that species. Lenz and Strunck (l.c.) have disagreed with this conclusion.

Locality.—N.Z. (Milne-Edwards, Miers).
Fairly common, from the extreme north to the extreme south (Filhol).
Portland Island, Bay of Islands, Lyttelton Harbour (G. E. Archey).
Sumner (Hutton).
Common in Otago under stones between tide marks (Thomson).
Common in Queen Charlotte Sound, Picton, etc.; many specimens collected all round the coast of Auckland; Moko Hinau, Hen and Chickens, etc. (C.C.).
Kaikoura, abundant among rock debris; Sumner, common among stones; Taylor's Mistake, Godley Heads, Lyttelton Harbour; Castlecliff (E.W.B.).
Portland Island (C. Riesop).
Stephens Island (T. B. Smith).
Akaroa (C.C.).
Robin Hood Bay, Marlborough (G. Bigg-Wither).
Dunedin (G. Marriner).

Distribution.—Australia.

Chasmagnathus subquadratus Dana.

Chasmagnathus subquadratus Dana, *U.S. Explor. Exped.*, vol. 13, Crust., pt. 1, p. 363, Pl. 13, Fig. 5. 1852.
—— Miers, *Cat. Crust. N.Z.*, p. 42. 1876.
—— Filhol, *Mission de l'Ile Campbell*, p. 391. 1885.
—— Haswell, *Cat. Crust. Austr.*, p. 106. 1882.
—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 238. 1913.

Hutton has queried the occurrence of this crab in New Zealand, and it is not known in New Zealand.

Chasmagnathus laevis Dana.

Chasmagnathus laevis Dana, *U.S. Explor. Exped.*, vol. 3, Crust., pt. 1, p. 365, Pl. 23, Fig. 7. 1852.
—— Miers, *Cat. Crust. N.Z.*, p. 42. 1876.
—— Haswell, *Cat. Crust. Austr.*, p. 106. 1882.
—— Miers, Zool. H.M.S. "Alert," p. 246. 1884.
—— Filhol, *Mission de l'Ile Campbell*, p. 391. 1885.
—— Fulton and Grant, *Proc. Roy. Soc. Victoria*, vol. 19, pt. 1, p. 19 1906.

This species depends on Miers' record, and, like the last, has been queried by Hutton.

Distribution.—Australia.

Helice crassa Dana.

Helice crassa Dana, *Acad. Nat. Sci. Philadelphia*, p. 252. 1851.
—— Dana, *U.S. Explor. Exped.*, vol. 13, Crust., pt. 1, p. 367, Pl. 23, Fig. 8. 1852.
—— Milne-Edwards, *Ann. Sci. Nat.*, vol. 20, p. 190. 1853.
—— Heller, *Reise der Novara*, Crust., p. 61. 1868.
—— Miers, *Cat. Crust. N.Z.*, p. 43. 1876.
—— Kingsley, *Proc. Acad. Nat. Sci. Philadelphia*, p. 220. 1880.
—— Haswell, *Cat. Crust. Austr.*, p. 107. 1882.
—— Filhol, *Mission de l'Ile Campbell*, p. 391. 1885.
—— Thomson, *Trans. N.Z. Inst.*, vol. 45, p. 238. 1913.

The third lateral emargination is often obsolete.

The resemblance of this species to *Hemiplax hirtipes*, though superficial, is remarkable; but the legs never have the long hairs possessed by that species, and the oblique crest on the external maxillipeds is fundamental and decisive.

See the note on the next species.

Locality.—N.Z. (Miers; Macleay Collection).
Auckland (Heller).
Sumner, Otaki (Hutton).
Mangrove swamp, Auckland Harbour; Tauranga; Heathcote Estuary (W. R. B. Oliver, T.N.Z.I., vol. 54, pp. 541-4).
Rangitoto, Waipara Beach (G. E. Archey).
Otago Harbour (G. R. Marriner).
Westland (J. W. Hende).
Waitangi Beach; mangrove swamp, Hokianga; Stewart Island; Heathcote Estuary; Onehunga, mudflats (C.C.).
Heathcote Estuary, mud flats; Sumner, under stones on sandy beach; Kairaki Beach, burrowing in hard sand above high-water mark; common (E.W.B.).

Distribution.—Australia.

Helice lucasi Milne-Edwards.

Helice lucasi Milne-Edwards, *Ann. Sci. Nat.*, ser. 3, vol. 20, p. 190. 1853.
—— Miers, *Cat. Crust. N.Z.*, p. 44. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 391. 1885.

We have not recognised this crab among our specimens of *Helice*, but have identified them all with *H. crassa*. The latter species was recorded from New Zealand by Heller and Miers, and though neither of these authors is reliable as regards localities, New Zealand workers have recognized *H. crassa* only. Yet Filhol did not record the latter, but reported *H. lucasi* to be abundant and wide-ranging. There is evidently some confusion, which we have been unable to clear up without seeing Dana's description of *H. crassa*. Filhol quotes several differences. If the two are synonymous, the name *H. crassa* has precedence.

Locality.—N.Z. (Milne-Edwards).
Cook Strait to Stewart Island; abundant at the Bluff (Filhol).

Distribution.—Endemic.

Sesarma catenata Ortmann.

Sesarma catenata Ortmann *Zool. Jahrb.*, vol. 10, p. 334, Pl. 17, Fig. 9. 1897.
Sesarma catenatum Stebbing, *Marine Investig. S. Afr.*, vol. 4, p. 44. 1905.

Ortmann quotes New Zealand as the locality from which his specimen was received, but adds the warning that this is by no means beyond doubt. As Stebbing has since recorded the species from South Africa, the suggested locality is almost certainly incorrect.

Sesarma pentagona Hutton.

Sesarma pentagona, Hutton, *Ann. Mag. Nat. Hist.*, vol. 15, p. 41. 1875.
—— Hutton, *Trans. N.Z. Inst.*, vol. 7, p. 279. 1875.
—— Miers, *Cat. Crust. N.Z.*, p. 44. 1876.
—— Filhol, *Mission de l'Ile Campbell,* p. 393. 1885.
—— Thompson, *Trans. N.Z. Inst.*, vol. 45, p. 238. 1913.

The inclusion of this crab in the New Zealand fauna rests on the specimen in the Wellington Museum described by Captain Hutton. Thomson (1913, p. 238) says there is a specimen labelled in Captain Hutton's handwriting in the Otago Museum but he has not come across the species elsewhere, nor have we. Miers says it is near *S. tetragona* Edw. and may be identical with it or one of the allied species. Its existence as a distinct species is therefore doubtful.

Percnon planissimum (Herbst).

Cancer planissimus Herbst, *Natur. d. Krabben u. Krebse,* vol. 3, pt. 4, p. 3, Pl. 59, Fig. 3. 1804.
Leiolophus planissimus Miers, *Cat. Crust. N.Z.,* p. 46. 1876.
—— Miers, *Ann. Mag. Nat. Hist.,* p. 153. 1878.
—— Haswell, *Cat. Crust. Austr.,* p. 112. 1882.
—— Filhol, *Mission de l'Ile Campbell,* p. 394. 1885.
—— Whitelegge, *Mem. Austr. Mus.,* 3, 2, p. 139. 1897.
—— Borradaile, *Proc. Zool. Soc.,* p. 592. 1900.
Percnon planissimum Rathbun, *Proc. U.S. Nat. Mus.,* vol. 38, No. 1766, p. 591. 1910.
—— Bouvier, *Bull. Sci. Fr. et Belg.,* vol. 49, fasc. 3, p. 130. 1915.

Many other references to this widely-spread and well-known species might be given. Miss Rathbun (l.c.) gives the following synonymy among the earlier literature:—*Cancer planipes* Seba, *Grapsus diris* Costa, *G. testudinum* Roux, *Ocypode* (*Acanthopus*) *clavimana* de Haan, *O.* (*A.*) *serripes* de Haan. The generic name is scarcely more fortunate, and Miers' name *Leiolophus* (which was proposed because de Haan's *Acanthopus* was preoccupied) must yield to *Percnon Gistel* 1898 (see Rathbun, l. c.).

In appearance, the crab resembles *Plagusia,* but is much depressed and has long legs.

Although Hutton included this species in his list of Crustacea which should probably be excluded from the New Zealand fauna, he has crossed the name off the list in his copy of the paper in question. We have apparently his authority for its occurrence here.

Locality.—N.Z. (Miers, Hutton MS.).

Distribution.—All warm seas.

Plagusia chabrus (Linnaeus).

Cancer chabrus Linnaeus, *Syst. Nat.,* ed. 10, p. 628. 1758
Plagusia capensis de Haan, Fauna Jap., Crust., p. 58. 1835.
Plagusia chabrus White, *Ann. Mag. Nat. Hist.,* vol. 17, p. 497. 1846.
—— Miers, *Cat. Crust. N.Z.,* p. 45. 1876.
—— Miers, *Ann. Mag. Nat. Hist*, ser. 5, vol. 1, p. 149. 1878.
—— Haswell, *Cat. Crust. Austr.,* p. 111. 1882.
—— Filhol, *Mission de l'Ile Campbell,* p. 393. 1885.
—— Miers, *Challenger Reports,* Zool., vol. 17, Crust., p. 273, Pl. 22, Fig. 1d. 1886.
—— Lenz, *Zool. Jahrb.,* vol. 14, p. 473. 1901.
Plagusia capensis Stebbing, *S. Afr. Crust.,* pt. 3, p. 47. 1905.
—— Stebbing, *Trans. Roy. Soc. Edin.,* vol. 50, p. 267. 1914.
Plagusia chabrus Fulton and Grant, *Proc. Roy. Soc. Victoria,* vol. 19, pt. 1, p. 20. 1906.
—— Rathbun, *Proc. U.S. Nat. Mus.,* vol. 38, p. 591. 1910.
—— Stebbing, *Ann. S. Afr. Mus.,* vol. 6, p. 322. 1910.
—— Lenz and Strunck, *Deutsche Südpolar Exped.,* vol. 15, p. 285. 1914.
—— Borradaile, *Brit. Antarct. Exped.,* 1910, Zool., vol. 3, p. 101. 1916.
—— Hale, *Crust. S. Austr.,* p. 185. 1927.

Locality.—Wellington, Cape Campbell (Hutton).
Cook Strait, Otago, Kapiti Island (Filhol).
Lyttelton (Hutton, G. E. Archey, C.C.).
Cuvier Island (Grenfell and Barr).
French Pass, Napier (Lenz).
Kaikoura, Lyttelton (E.W.B.).
Napier; Portland Island; frequently seen in rock pools at low tide at Slipper Island and other Auckland localities during the "Hinemoa" trip, 1914-15, but it is very active and alert and was very difficult to catch. (C.C.).

Distribution.—Chili, Juan Fernandez, Tongatabu, South Africa, Australia, Tasmania, Kermadec Islands, Lord Howe Island, Norfolk Island.

Calappa hepatica (Linnaeus).

Cancer hepaticus Linnaeus, *Mus. Lud. Ulrici*, p. 448. 1764.
Calappa tuberculosa Guerin, *Icon. R.A.*, Crust., Pl. 12, Fig. 2.
Calappa hepatica de Haan, *Fauna japonica*, Crust., p. 70. 1883.
—— Ortmann, *Zool. Jahrb.*, vol. 6, p. 568. 1892.
—— *Zool. Forschungsreisen in Austr.*, vol. 5, lief. 1, p. 35. 1894.
—— Alcock, *Journ. Asiatic Soc. Bengal*, vol. 45, p. 142. 1896.
—— Whitelegge, *Mem. Austr. Mus.*, vol. 3, p. 139. 1897.
—— Borradaile, *P.Z.S.* for 1900, p. 572. 1900.

Ortmann (1894) includes New Zealand in his account of the distribution, but the reference requires verification.

Pinnotheres.

The pea-crabs, commensal with various Pelecypoda (*Mytilus. Mactra, Spisula, Atrina*) are common in New Zealand, and our collections contain specimens from many localities. We have not revised the genus in the present paper, and merely note that the following have been recorded from New Zealand:—

Pinnotheres pisum Linnaeus.
Pinnotheres novae-zealandiae Filhol.
Pinnotheres schauinslandi Lenz.

This is by no means a satisfactory list. *P. pisum*, for example, is the European species and is probably correctly identified, but various writers (Heller, Miers, Filhol) who have identified New Zealand specimens with that species have commented on the identity of the New Zealand mussel in which it lives with the European mussel *Mytilus edulis*, but as a matter of fact our mussel has been masquerading under a wrong name, and is *Mytilus planulatus* Lamarck, quite distinct from the European species (W. R. B. Oliver, "Notes on New Zealand Pelecypods," *Proc. Malac. Soc.*, vol. 15, pt. 4, 1923). Again, *Pinnotheres schauinslandi* was described by Lenz (*Zool. Jahrb.*, vol. 14, p. 468, 1901) from two specimens of which we do not even know the sex, and the validity of the species has already been

questioned by the senior author (Chilton, *Rec. Cant. Mus.*, vol. 1, part 2, p. 295, 1911). *Pinnotheres novae-zealandiae* appears to be a valid species, and has recently been recorded from Australia by Miss Rathbun (*Sci. Results "Endeavour" Exped.*, p. 98, Pl. 16, Fig. 2, and text Fig. 2, 1923). Gurney has recorded Zoeae stages of a *Pinnotheres* from North Cape and Bay of Islands (*Brit. Ant. Exped.*, Zool., vol. 8, p. 195, 1924), but his identification with *P. pisum* is probably only a guess.

Halicarcinus, etc.

The remainder of the crabs recorded from New Zealand but not discussed above are all small, the carapace rarely if ever exceeding an inch in length or breadth. Some species are common and widely distributed, especially *Halicarcinus planatus*. This species may be taken as a type of the algae-frequenting forms, which are comparatively active, while *Hymenicus pubescens* is an example of those found under stones and in crevices. The latter species is covered with grey hairs, and very inconspicuous, especially as it is minute, and clings motionless to the rock; and, as might be expected in such small and defenceless creatures, there are several other examples of protective colours and habits. *Hymenosoma lacustris* is especially interesting in that it is the only fresh-water crab in New Zealand.

In the following list, a few bibliographical references are added which are of special value, or which might be passed over in compiling a bibliography; other references will be found in the works referred to under other species. The query after *Elamena whitei* indicates that the species has been challenged.

Halicarcinus planatus Fabricius.
—— Chilton, *Subant. Isl. N.Z.*, vol. 2, p. 609. 1909.
—— Rathbun, *Austr. Ant. Exped.*, vol. 5, pt. 2.
—— (= *H. ovatus* Stimpson, *Proc. Acad. Nat. Sci. Philad.*, p. 109, 1858; Hale, *Crust. S. Austr.*, p. 117, 1927; Miers, Zool., H.M.S. "Alert," p. 248, 1884).
Halicarcinus tridentatus Jacquinot and Lucas, *Voyage au Pol Sud*, Zool., vol. 3, p. 60, Pl. 5, Fig. 27. 1853.
—— Chilton, l.c., 1909, and *Rec. Cant. Museum*, vol. 1, No. 2, p. 293. 1911. (*H. planatus* var. *tridentatus*).
Halicarcinus huttoni Filhol, *Mission de l'Ile Campbell*, p. 398.
Hymenicus varius Dana, Miers, *Cat. N.Z. Crust.*, p. 50.
Hymenicus pubescens Dana, Miers, l.c., p. 51.
Hymenicus edwardsi Filhol, l.c., 400.
Hymenicus cooki Filhol, l.c., p. 401.
Hymenicus haasti Filhol, l.c., p. 402.
Hymenicus marmoratus Chilton (? = *H. varius* Dana).
Hymenosoma depressum Jacquinot and Lucas.
—— Chilton, l.c., 1909, and *Ann. Mag. Nat. Hist.*, ser. 7, vol. 19, p. 148, Pl. 5, Figs. 1-4. 1907.
Hymenosoma lacustris Chilton, *Trans. N.Z. Inst.*, vol. 47, p. 316. 1912.
Elamena quoyi Milne-Edwards.
Elamena whitei Miers (?).
Elamena longirostris Filhol, l.c., p. 403.

Elamena kirki Filhol (= *E. producta;* see Chilton, *Rec. Cant. Mus.*, vol. 1, No. 3, p. 294. 1911).
Elamena producta Kirk.
Ebalia laevis Bell.
—— Chilton, l.c., 1911, and *Trans. N.Z. Inst.*, vol. 38, p. 266. 1906.
Ebalia cheesemani (Filhol), l.c., p. 407.
Ebalia tumefacta Mont, Filhol, l.c., p. 407.
Ebalia tuberculosa Milne-Edwards.
—— Whitelegge, *Mem. Austr. Mus.*, Mem. 4, vol. 2, p. 161.
—— Rathbun, "*Endeavour*" *Sci. Results*, p. 134, Pl. 35, Figs. 1-2. 1923.
—— Rathbun, *U.S. Comm. Bull.*, pt. 3, p. 889. 1903.
—— Ortmann in Bronn's Thierreich, Bd. 5, abt. 2, p. 120, Fig. 10. 1899.

INDEX.

Key to Code Letters in Index—

a. Authentic New Zealand species.
b. Probably true species occurring in New Zealand, but not endemic.
c. Species of doubtful authenticity.
d. Foreign species perhaps not occurring in New Zealand.
e. Foreign species almost certainly not occurring in New Zealand.
f. Endemic.
g. Endemic species known from original description only.

Fresh-water Fauna of New Zealand, Contributions to a Knowledge of.

By DR. V. BREHM, Biological Station, Lunz, Austria.
(Translated from the German and communicated by E. W. Bennett.)

[*Read before the Canterbury Philosophical Society, 6th June, 1928; received by Editor, 8th June, 1928; issued separately, 25th March, 1929.*]

PART 1.—ON THE MICROFAUNA OF A POND IN A SPHAGNUM-BOG ON MOUNT ROLLESTON.

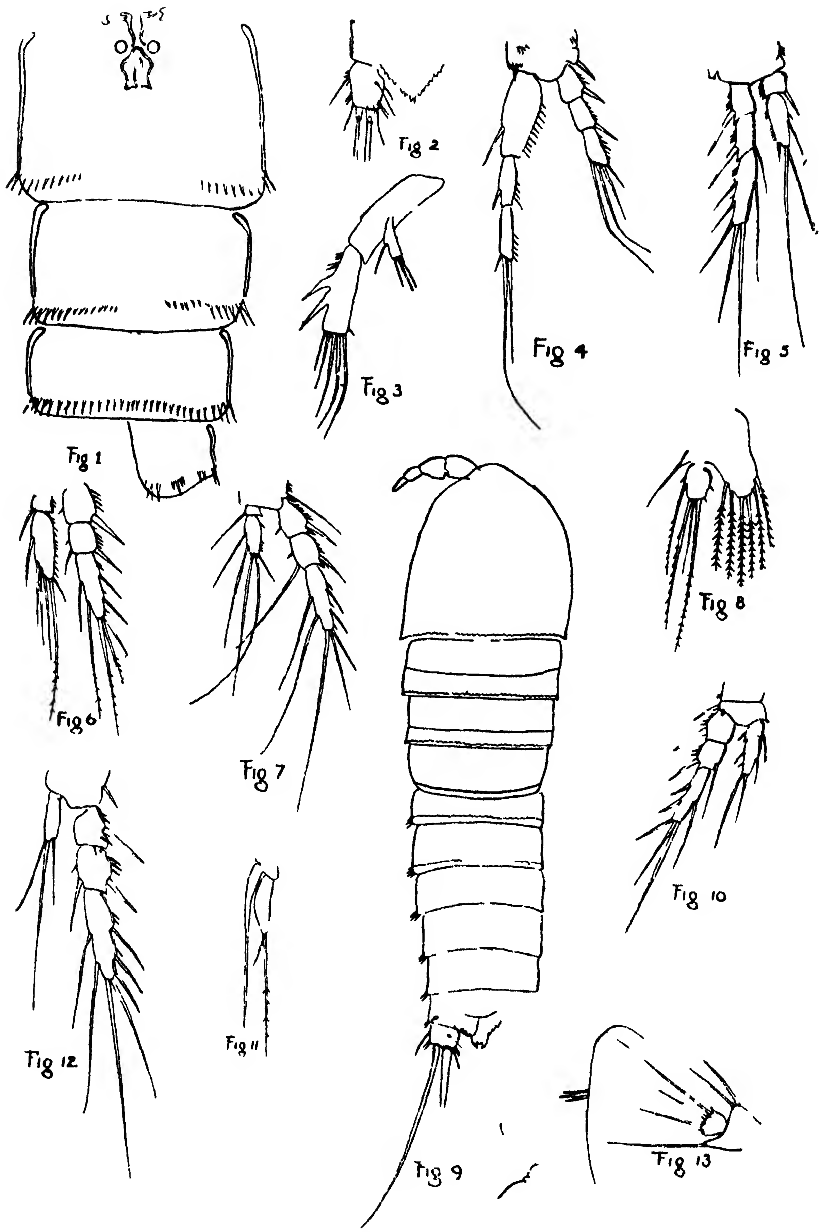
DURING the course of studies preliminary to writing a treatise on the "Tiergeographie des Süsswassers," I have found it essential to secure further information concerning certain regions which have a special significance in connection with the geographical distribution of animals. Of such regions, New Zealand stands in the front rank. Mr. E. W. Bennett, of Canterbury College, Christchurch, has been kind enough to forward material to me for investigation, for which I wish to express my heartiest thanks. As, however, I am also engaged at the present time on a study of Japanese and South American material, the examination of the collections from New Zealand is proceeding slowly; and for this reason, and also because there are many details which cannot be settled at once on account of the deficiencies in the literature, I propose to offer short reports from time to time as the work proceeds. The following paper, the first of the series, deals with the micro-fauna of a small tarn in a moss-bog which is situated on Mount Rolleston, near Arthurs Pass.

Entangled in a mass of *Sphagnum* and unicellular swamp-algae in a specimen-tube, were a number of fine shelled Rhizopoda, among which I recognized representatives of the genera *Nebela, Assulina,* and *Euglypha.* To make certain of these Rhizopods, I sent a small tube to the illustrious authority on the group, Herr E. Penard, of Genf, who was kind enough to look through the material. My sincerest thanks are here offered to Herr Penard for this service.

COPEPODA.*

Of the contents of the tube, the Harpacticidae are without doubt the most interesting, partly because extremely little has hitherto been known of this group as represented in the Southern Hemisphere, and partly because this tube leads one to expect a preponderance of this section of the Copepoda similar to that which Delachaux has recently revealed in the case of the lakes of the Peruvian Andes—with which region, in fact, New Zealand and Australia have much in common, as for example the occurrence of the Boeckellidae.

*The five new species of Copepoda described in this section have already been named and briefly characterized in "Vorlaüfige Mitteilung über die Süsswasserfauna Neu-Seelands," *Zoolog. Anzeiger*, Bd. 75, Heft 7/10, pp. 223-225, 15th Feb., 1928.



FIGS. 1-13.—*Delachauxiella Bennettii* n. sp.

1. ♀, abdomen, ventral;
2. ♀, furca and anal plate, dorsal;
3. ♀, 2nd antenna;
4. ♀, first foot,
5. ♀, second foot;
6. ♀, third foot;
7. ♀, fourth foot;
8. ♀, fifth foot;
9. ♂, dorsal view, and anal plate of a second specimen;
10. ♂, second foot;
11. ♂, inner branch of third foot;
12. ♂, fourth foot;
13. ♂, fifth and "sixth" foot.

No species of fresh-water Harpacticidae appear to have been hitherto recorded from New Zealand, and only two are known from Australia, viz., *Attheyella australica* Sars and *Moraria longiseta* Henry; but neither of these species shows any special relationships with the fauna of South America. The collection from Mount Rolleston contains representatives of two different types, viz., larger species of the *Canthocamptus* type, and smaller ones of the *Moraria-Parastenocaris* type. These comparisons merely indicate their general aspects, and should not be interpreted as implying anything concerning their true systematic relationships. Those who have investigated the Harpacticidae know that the taxonomy of the group is at present in a most difficult condition, because no adequate basis has been discovered for a satisfactory delimitation of the genera. Although Graeter has shown the untenability of the method in other groups of Copepoda, the number of joints in the antennae or in the inner and outer branches of the swimming-feet is still commonly made use of in defining the genera, so that species are grouped into quite untenable genera such as *Attheyella, Mesochra,* etc. By a consistent extension of Graeter's point of view, Kiefer has just worked out a welcome reconstruction of the classification of the Cyclopidae. Among the Harpacticidae in which the relationships certainly appear to be more difficult to detect, Haberbosch has attempted a similar investigation, without however succeeding in reaching a tangible result. Hence in attempting to place the new species described below in existing genera, there are very considerable difficulties in the way.

In studying the Entomostraca of South America, the author has laid stress on those species of *Canthocamptus,* hitherto known only from that country, which are distinguished by a triangular or arrow-head-shaped anal plate; and for these he has founded the genus *Delachauxiella*. The opinions of specialists are divided on the question of the validity of this genus. In regarding the characteristics which were used for the definition of the genus as being of phylogenetic significance, the author was influenced by the fact that all of these species were known exclusively from South America. Certainly the objection can be raised that the genus *Moraria,* which can be separated from *Canthocamptus* only with difficulty, possesses triangular and frequently toothed anal plates, and that, moreover, in European representatives of the genus. On the other hand, the presence of two such species in New Zealand serves admirably for the geographical and morphological distinctness of the genus, and the genus *Delachauxiella* as defined by me may therefore be upheld, and two of the following new species placed in it.

1. **Delachauxiella Bennettii** n. sp.

This species is by far the most abundant Harpactid in the available material, and is represented by both sexes and by different stages of growth.

Female: A mature female, carrying six colourless eggs in an egg-sac, was 0.75 mm. in length without the furcal setae, and 1 mm. with them. These may be taken as the average dimensions; but a mature female scarcely 0.7 mm. in length was also found, and on

the other hand another reached the length of 1 mm. without the furcal setae.

The hinder edges of the thoracic segments are finely dentate. Of the abdominal segments, the last bears a continuous margin of spinelets on the ventral surface, while in the two preceding segments the row of spinelets is interrupted in the middle.

In the first pair of feet, both branches are three-jointed and without any striking peculiarities. In the second, third, and fourth pairs, the inner branches are only two-jointed. The armature is indicated in the accompanying figures. In the fifth pair, the inner part of the basal joint is broadly produced, and bears six almost equally long and sparsely-haired setae, while the second is oval and bears only four.

The anal plate is small and triangular, and armed at the edge with 5-7 somewhat distant teeth; at the end it usually runs out into a double tooth or two-pronged middle piece, but less frequently the point is produced into a single median tooth. (Fig. 2).

The furcae are slightly longer than broad, and bear two well-developed furcal setae, of which one is about half as long as the other.

The head has no distinct rostrum. The first antenna is 8-jointed. The sensory hair of the fourth joint extends considerably beyond the end of the antenna. The end-joint of the second antenna has five setae, regularly arranged according to length, and two strong lateral spines. The appearance of the female genital area is indicated in Fig. 1.

Male: The most obvious differences between the male and the female are the more slender proportions of the former, the fewer lateral teeth on the anal plate (usually only three), and the furcae, which are shorter and almost square in shape. The differences in the armature of the swimming-feet are shown in the accompanying figure. The inner branch of the third pair bears on the inner side of the second joint a spine which runs out into a smooth spine without a hook.

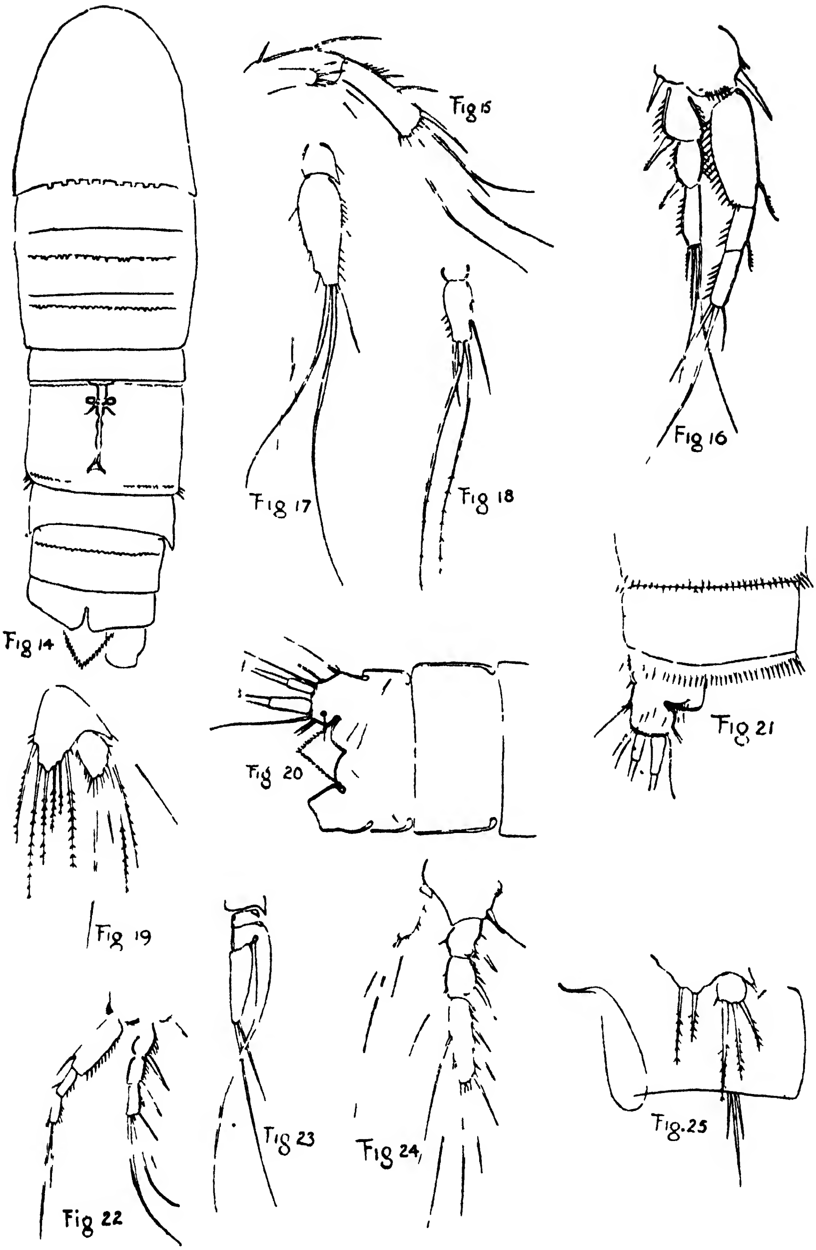
The rudimentary fifth feet bear only two setae on the inner part, and only three on the broadly-oval terminal joint.

A specimen of a female Canthocamptid was discovered, which differed from all the other Harpactids in the tube in that it possessed a semi-circular untoothed anal plate, so that at first I thought that I had another new species. But a more detailed examination showed that this specimen agreed so thoroughly in all other details with *D. Bennettii* that it must certainly be included in the latter species. The abnormal form of the anal plate will probably have to be interpreted as a mutation of *D. Bennettii.*

2. **Delachauxiella** (= *Canthocamptus* auct.) **insignis*** n.sp.

Another species which occurred much less commonly in the collection than *D. Bennettii* had likewise a triangular anal plate; the latter, however, was not provided with small marginal notches, but with long and slender teeth, so that the edge could almost be

*On account of the distinctive square processes on the hinder edge of the first cephalothoracic segment.



FIGS. 14-25.—*Delachauxiella* (*Canthocamptus*) *insignis* n. sp.

14. ♀, dorsal;
15. ♀, second antenna;
16. ♀, first foot;
17. ♀, inner branch of third foot;
18. ♀, inner branch of fourth foot;
19. ♀, fifth foot;
20. ♂, abdomen and anal plate;
21. ♂, abdomen, ventral;
22. ♂, first foot;
23. ♂, inner branch of third foot;
24. ♂, fourth foot;
25. ♂, fifth and "sixth" foot.

described as fringed. Perhaps it agrees in this respect with *Moraria longiseta* Henry from New South Wales, of whose anal plate the discoverer of the species remarks that it is "fringed with hairs"; the figure agrees with this account. But one could scarcely describe the anal plate of the present species as haired; the armature of the edge could rather be compared with the teeth of a comb. It is, however, easily seen that our species has nothing to do with the *Moraria* in question—as shown at first glance by the shortness of the furcae, not to mention many other differences.

Male: Including the furcal setae, the body is about 0.8 mm. in length. The cephalothoracic segment bears at its hinder edge a series of remarkable and almost square prolongations. The hinder edges of the following segments are finely and irregularly produced. The last three abdominal segments bear a continuous row of spinelets on the ventral surface.

The furca is broader than long, bears two well-developed terminal setae, whose length is about 0.26 mm., and otherwise shows no characteristics of note. The anal plate is triangular in shape, as mentioned above, and bears along the edge on each side about 15 long and slender teeth.

Both branches of the first pair of legs are three-jointed, while the inner branches of the remaining pairs are two-jointed. The characteristic spine of the third pair ends in a smooth point without a hook. The fifth pair bears two almost equally long setae on the slightly-produced inner part of the basal joint; the second joint is rounded and bears three setae.

Female: About 0.7 mm. in length without the furcal setae. The hinder edge of the cephalothoracic segment shows the same remarkable square-shaped projections as in the case of the male, and the hinder edge of all the following segments are finely and irregularly produced. The hinder edge of the last three abdominal segments bears a long fringe of spinelets, which in the third last is interrupted in the middle.

The furcae and anal plate show no essential differences from those of the male. The sculpture of the genital area is shown in the accompanying figure.

The first pair of legs has both branches three-jointed, while the inner branches of the following pairs are only two-jointed. Differences are found between the right and left limbs in the number of setae on the terminal joints of the inner branches.

In the fifth pair, the inner part of the basal joint is strongly produced posteriorly, and bears six sparingly plumose setae. The terminal joint has four setae. Another difference between the right and left appendages occurs here, the prolonged part of the basal joint of the left pair having only five setae.

3 **Canthocamptus misogynus*** n. sp.

Another species of a Canthocamptid was represented by only a single male; the length was about 0.8 mm. with the furcal setae, and about 0.6 mm. without them.

*Because found without the female.

The last abdominal segments bear an uninterrupted row of spinelets on the ventral side. The anal plate is flatly curved, and provided with numerous delicate teeth, so that it could almost be said to be ciliate. The furcae are almost square; the terminal setae are both well developed, the one being about twice as long as the other; the rest of the armature of the furcae is rather sparse, as indicated in the figure. The dorsal seta missing from the figure was evidently broken off during the preparation of the specimen.

The first pair of feet has the inner and outer branches both three-jointed. There is a notable plumose fringe on three lateral hairs of the last and second last joints of the inner branch, as shown in figure 27.

The second pair of feet has only a two-jointed inner branch; the distal outer corners of the joints of the outer branch are produced outwards into sharp points. These points are more strikingly developed in the corresponding joints of the third feet. The spine of the second joint of the inner branch of the third foot is as long as the exopodite and does not terminate in a hook.

The fourth pair is characterized by a very long exopodite, whose joints are well provided with setae and spinelets. The endopodite is two-jointed and very short, the first joint being very small.

The rudimentary fifth feet show on the slightly-produced inner part of the basal joint two setae of unequal length. The second joint is slightly broader than long, and bears at the distal edge five short spines and three setae.

4. **Canthocamptus maoricus*** n.sp.

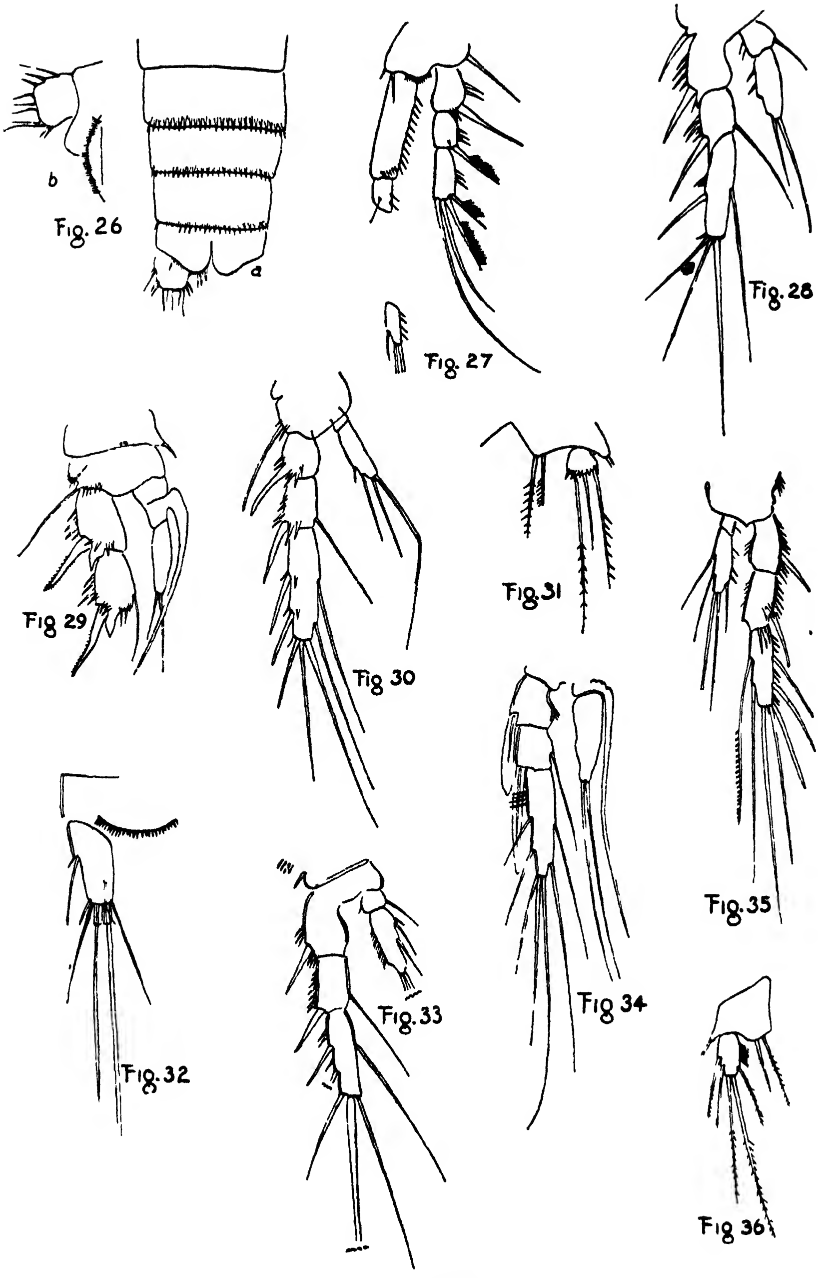
A further Canthocamptid was represented by a single male specimen, of which unfortunately only a very incomplete account can be given; the description below, however, will sufficiently characterize the species to enable it to stand as valid.

Length 1 mm. Second pair of legs with a two-jointed inner branch. Third pair remarkable on account of immense, broad, and blunt blades on the first and second joints of the outer branch. The spine of the inner branch runs out into a simple point without a hook. The fourth pair likewise has a two-jointed inner branch; the three joints of the outer branch bear remarkably blunt spines on the outer edges. The proximal seta of the inner edge of the last joint of the outer branch is characteristically toothed.

A slight asymmetry occurs in the fifth pair; on the one leg, the second joint bears five setae, and in the other the proximal seta of the outer edge is modified into a small spine. Such cases of asymmetry in other species have frequently been regarded as abnormalities, but the general tendency towards asymmetry in the Copepoda suggests that possibly the asymmetry may be a constant condition. As only the one specimen was forthcoming, however, it must remain undecided in the meantime which of these possibilities is correct.

The furcae are fully twice as long as broad. The anal plate is flatly curved and armed with 25 long spines.

*On account of its occurrence in New Zealand, the home of the Maori.


b
a
Fig. 26
Fig. 27
Fig. 28
Fig 29
Fig 30
Fig. 31
Fig. 32
Fig. 33
Fig 34
Fig. 35
Fig 36

FIGS. 26–36.

Four specimens of a Harpactid differed from those described above, through their smallness and slender form; I refer them only provisionally to the one species. They were as follows:—

(1) One immature specimen of doubtful sex;
(2) A male;
(3) Two females.

The two females differed from one another in certain respects, and there is at least a possibility that they may belong to two different species, in which case it would remain doubtful to which of the females the above-mentioned male would belong. As I find a difficulty in assigning these specimens to any of the existing genera, I intend to found a new genus for them; but in the meantime I postpone the definition of the latter until further details can be given in a later treatise.

5. **Antipodiella chappuisi** n. sp.

Female: Length 0.6 mm. including the terminal setae. Margins of the segments smooth. The surface-design of the genital segment is shown in the figure. Antenna 8-jointed; the sensory hair of the fourth joint extends beyond the end of the antenna for quite the length of the last two joints. The swimming-feet have a three-jointed outer and a two-jointed inner branch. The inner part of the basal joint of the fifth foot is scarcely produced, and bears five almost equally long and sparingly plumed setae. The second joint of this foot bears four setae—a long one at the inner corner, then a shorter and more slender one, then two subequal setae of moderate length The furcate are 2½ times as long as broad; the outer edge bears two setae, each accompanied by a small spine, and at the end is a basally swollen and onion-shaped seta, which is scarcely longer than the furca, and is flanked on either side by a short and slender seta. In a second specimen, however, the long terminal seta was about twice as long and the basal part did not show the onion-shaped swelling. Since in adition the anal plate of the first specimen was furnished with a marginal fringe of hairs, and no such feature occurred on the second specimen, the edge of the plate being quite smooth, it may be that two closely related yet nevertheless distinct

FIGS. 26-31.—*Canthocamptus misogynus* n. sp.

26. ♂, ventral view of abdomen and furca; and anal plate.
27. ♂, first foot; last joint of the inner branch broken off, but the fragment figured was found with the rest of the preparation and agrees well.
28. ♂, second foot; some spines have probably been broken off from the second joint of the inner branch.
29. ♂, third foot; last joint of the outer branch broken off.
30. ♂, fourth foot;
31. ♂, fifth foot.

FIGS. 32-36.—*Canthocamptus maoricus* n. sp.

32. ♂, furca and anal plate;
33. ♂, second foot;
34. ♂, third foot;
35. ♂, fourth foot.
36. ♂, fifth foot.

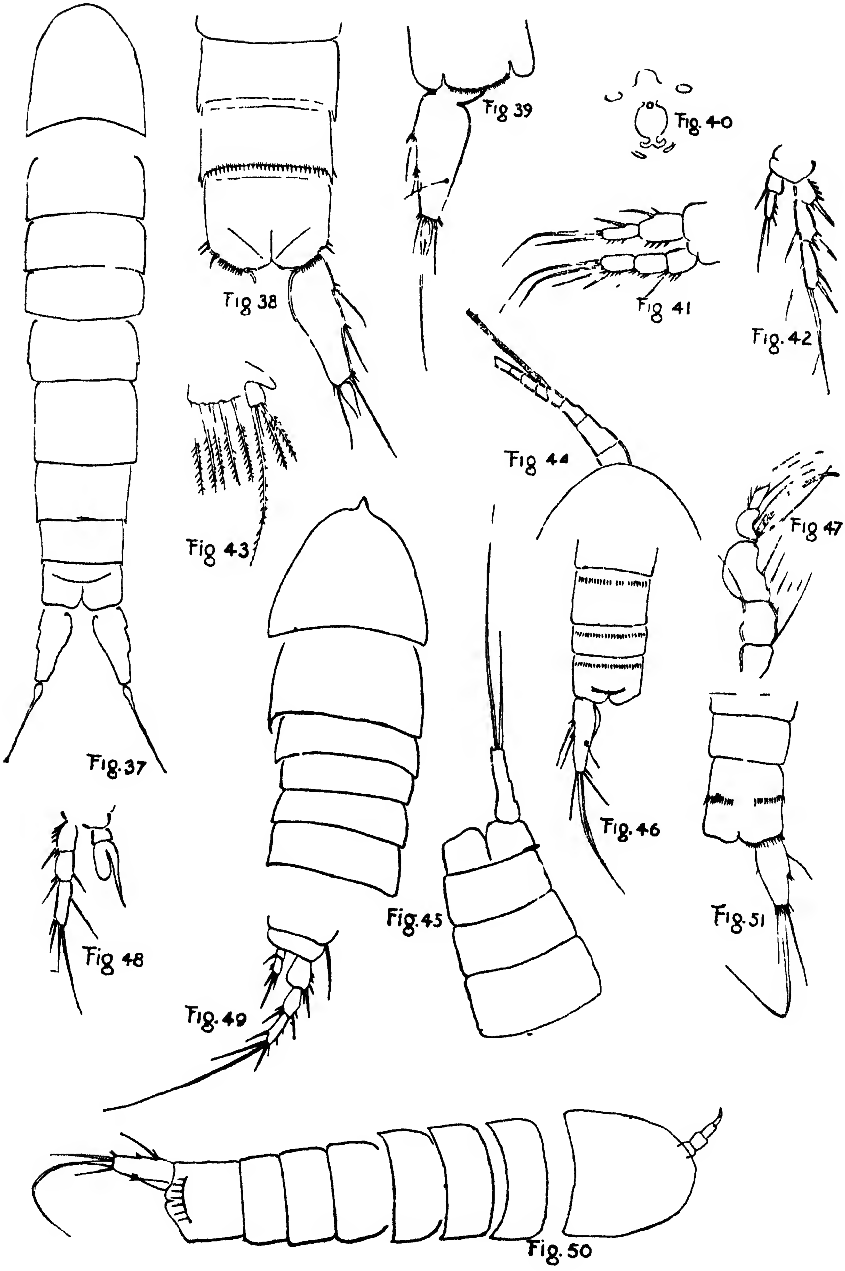


Fig.37
Fig 38
Fig 39
Fig. 40
Fig 41
Fig. 42
Fig 43
Fig 44
Fig.45
Fig. 46
Fig 47
Fig 48
Fig. 49
Fig. 50
Fig. 51

Figs. 37-51.

species are represented here; but it may simply be that the former species has a wide range of variation.

Male: The only male specimen found measured 0.5 mm. in length inclusive of the furcal setae. The hinder edges of the segments were simple on the dorsal side, while the last three abdominal segments each bore on the ventral side a continuous fringe of spinelets. The first antenna had a very long and stout sensory hair on the fourth joint. The accessory branch of the second antenna was noticeably small.

The inner branch of the third pair of feet bore a short and broad blade, which ended in a smooth point. The terminal joint bore no setae, and showed no sign that the latter might have been broken off. The outer branch of the fourth pair was three-jointed and the inner branch two-jointed. Of the fifth pair I did not succeed in obtaining more than an incomplete and doubtful figure, which I offer with due reservation. It would appear that the inner part of the base is not prolonged, and that it bears only one seta, the terminal joint having three. The possibility of error, however, is not excluded in this interpretation. At all events, the so-called sixth pair of feet was represented in this male only by a single spine.

The above-described male, which, though it reached a length of almost 0.5 mm., was evidently not yet mature, is figured in order to show particularly the remarkable armature of the flatly-curved anal plate, which bore seven long needle-shaped teeth.

The provisional generic name should serve as a reminder of the occurrence of this species in the Southern Hemisphere; the specific name is bestowed in honour of Dr. P. A. Chappuis, the chief authority on the Harpacticidae.

RHIZOPODA.

Unfortunately the samples forwarded to Herr Penard included only some of the forms which came under my notice. Nevertheless Dr. Penard's report forms a substantial contribution towards the elucidation of the fresh-water fauna.

FIGS. 37-51.—*Antipodiella chappuisiella* n. sp.
37. ♀, dorsal view;
38. ♀, abdomen and furca, ventral view;
39. ♀, ditto, dorsal view;
40. ♀, sculpture of the genital area;
41. ♀, first foot;
42. ♀, third foot;
43. ♀, fifth foot.
44. ♀, first antenna (from a second specimen);
45. ♂, outline;
46. ♂, abdomen and furca, dorsal, with the spinelets of the ventral surface showing through;
47. ♂, modified antenna;
48. ♂, third foot;
49. ♂, fourth foot;
50. An immature specimen (?);
51. Abdomen and furca of the latter specimen.

Of a *Nebela,* which was by far the most abundant and remarkable form—as also in the samples which I investigated—Dr. Penard writes*:—

"It is similar to *Nebela vas* Certes, but differs therefrom in that the shell possesses a broad, hollow, and characteristic keel, which is always present and might well be regarded as a sufficient character to distinguish a new species. I have not been able to identify it with any known species."

Unfortunately only empty cases of this fine Rhizopod were found. Before the natural colours and the characteristics of the protoplast could be determined, it would be necessary to obtain living specimens of the animal—which indeed could easily be accomplished by a zoologist living in New Zealand. On account of Herr Penard's long-continued experience and acquaintance with the Rhizopod group, the short statement of such an authority is amply sufficient for the announcement of this *Nebela* as a new species, and I propose to name it *Nebela Penardi* n. sp.

Less abundant and also less remarkable is another species which is undoubtedly identical with *Nebela Certesi* Penard, which was described by Certes as a variety of *Nebela collaris.* It may be regarded as a Pacific species, and has already been recorded from New Zealand (Penard, "Rhizopodes d'eau douce," in *Brit. Antarctic Exped.,* 1907-1909).

Herr Penard has also detected two other small species of *Nebela* which could not be precisely determined; a *Euglypha* which is quite identical with *Euglypha ciliata*; and a *Difflugia* which unquestionably belong to *Difflugia acuminata.*

Rotatoria.

The collection contained an abundance of *Anuraea cochlearis,* which is noteworthy, as *Anuraea serrulata* is likewise regularly found in European bog-mosses.

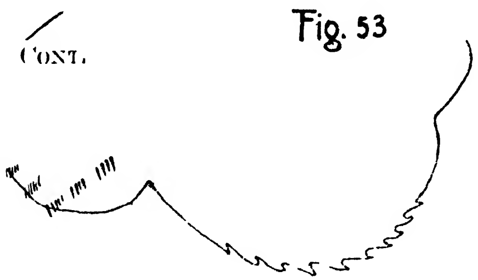
Numerous specimens occurred of *Dissotrocha aculeata* Ehbg., in a form, however, characterized by having only two wing-like laterally situated spines. For the determination of this species I am indebted to Dr. David Bryce. Since all of the specimens in the available material were provided with only two such wing-like spines, it is evidently not a case of individual variation, but of a thoroughly established strain.

Some Rotifer loricae were also fairly common, which agree so completely with those of *Callidina angusticollis* Murray that there can be no doubt as to their identity with that species. Herr Penard drew my attention also to the presence of the loricae of a second Rotifer which perhaps belongs to *Habrotrocha perforata*; I found it also in the material which I examined, often clinging to *Sphagnum* leaves.

*Translation.

Isolated specimens were also found of *Monostyla crenata* Harring; this species has already been recorded from Australia and New Zealand by Murray.

One specimen of *Cephalodella mucronata* Myers was also discovered. Murray, who first described the species from eastern North America, has already noted that though he recorded it as new it had already been found; but the identification had been incorrect, as Murray had described it from New Zealand under the name of *Monommata appendiculata*.



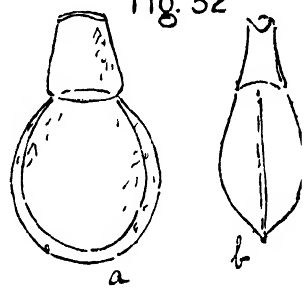


FIG. 52.—*Nebela Penardi* n. sp.
a, side view; *b*, end view.

FIG. 53.—*Streblocerus serricaudatus* var. *Novae-Zelandiae* n. var. postabdomen.

CLADOCERA.

A number of specimens of a small form belonging to the Cladoceran genus *Alona* were present in the tube, but I have deferred the determination of these, partly because of the extraordinarily trifling value of these *Cladocera* from the point of view of animal geography, and partly because of the present unreliable state of the classification of this group of *Cladocera*, where almost every species has dozens of badly described synonyms, the arrangement and reduction of which has only just been taken in hand by some of the more recent authors.

The species *Streblocerus serricaudatus* was abundantly represented in both sexes. This species is thus now recorded for the first time from the southern hemisphere, whence only the second species of the genus, *S. pygmaeus*, a Brazilian form, has hitherto been known. The New Zealand form differs from the typical *S. serricaudatus* of North Europe, North Asia, and North America, in the following points:—

1. The post-abdomen is more richly provided with lateral rows of spinelets, and the proximal serrated segment is more prominent.

2. The vales of the shell are finely granulated, not polygonally sculptured.

The New Zealand form may therefore be distinguished from the typical species as *Streblocerus serricaudatus* var. *Novae-Zealandiae*. The most southern locality of the species has hitherto been Stingelin's record from mountain lakes of Columbia. (Fig. 53).

If the above account is reviewed with the purpose of making a comparison with the fauna of a European *Sphagnum* bog a considerable degree of ecological similarity is evident. But whereas the European *Sphagnum* contains usually only one Canthocamptid and rarely about one *Parastenocaris*, yet a considerable number of these forms are represented in the New Zealand material—a phenomenon which we do not regard as an exception but which we have to recognize as a peculiarity of the southern hemisphere.

Hydracarina and Ostracoda are quite absent from the material discussed in this paper. Nematodes were only very sparingly represented and must remain unidentified, as must also be the case with some Oribatidae and insect-larvae of which a small Tan... accom- noticed but not further identified. ...unt of Herr

Rotifers were more plentiful, but included ver... nce with the and none at all of the species typical of the Euro... hority is amply such as *Anuraea serrulata, Microdon clavus, Ploesoma*, or *E*...ies, and In spite of this, the *Sphagnum* waters of Mount Rolleston remind us forcibly, through their Rhizopod fauna and the presence of *Streblocerus*, of the analogous faunistic areas of Europe.

At all events, the results obtained from this single tube justify the wish that collections might be procured from other localities in the mountain ranges of New Zealand in order that the picture of the New Zealand fauna might be completed.

Fresh-water Fauna of New Zealand.

NOS. 2–6.

BY DR. V. BREHM, Biological Station, Lunz, Austria.
(Communicated by E. W. BENNETT).

[*Read before the Philosophical Institute of Canterbury, 3rd October, 1928; received by Editor, 5th December, 1928; issued separately, 25th March, 1929.*]

CONTENTS:—

SINCE the former paper was written, some more of the collections kindly forwarded by Mr. E. W. Bennett have been examined, and the further information which has been obtained on the fresh-water fauna of New Zealand is recorded in this paper, independently of strict systematic sequence.

2. THE PLANKTON OF LAKE LYNDON.

The plankton collections from Lake Lyndon, which is 2,743 feet above sea-level, are remarkable in several respects. The absence of Rotifers (with one exception) and of plankton Diatoms and Peridinians may perhaps be attributed to the use of a net with too wide a mesh to retain the smaller organisms†; but on the other hand the absence of the genera *Daphnia* and *Cyclops* may be safely regarded as a genuine peculiarity of the lake, which is remarkable for the fewness of its planktonic species.

The components of the plankton were as follows:—

1. A species of the family Boeckellidae, which will be dealt with elsewhere;
2. *Ceriodaphnia* spec.;
3. *Bosmina hagmanni.*;
4. *Asplanchnopus myrmeleo.*

Some accompanying explanation of the use of the names in this list will be necessary.

Ceriodaphnia spec. was present in incredible numbers, and was distinctly the dominant form in the plankton. Yet no ephippium-

*For No. 1, see Trans. N.Z. Institute, vol 59, p. 779, 1928.

†The net was a seven-foot surface-net of sign-writers' muslin, operated from a row-boat. The paucity of species may in part be due to the violent storm and heavy rain at the time of collecting; but on the other hand I found no recognisable plankton at all in a similar locality (the Intake, Lake Coleridge), where I operated the same net during fine weather on the following day.—E.W.B.

bearing females and no males were found, and this makes it necessary to leave the identity of the species an open question at present. The following are the records, as far as I have determined, of *Ceriodaphnia* from Australia and New Zealand: Miss Henry has reported *C. cornuta, C. spinata,* and *C. honorata* from the continent, Gurney has added *C. dubia* from Queensland, and Smith has described *C. hakea* and *C. planifrons* from Tasmania. Moreover, Sars has recorded *C. dubia* from Lake Wakatipu in New Zealand.

The Tasmanian forms and *C. honorata* can scarcely be included in a survey, for the accounts of these species are scarcely sufficient for their clear recognition. The accounts of *C. dubia* do not quite agree with one another. Gurney refers, in the course of his description of the Queensland specimens, to Stingelin's proposal to unite *C. dubia* and *C. reticulata,* and rejects the proposal because the Queensland specimens have no such pronounced lateral crest on the terminal claw. And moreover there is a striking difference between the two species in the form of the male antennule; but since no males are present in my collection, an essential point of comparison is lacking. However, Gurney definitely states that a lateral crest is present in his specimens; and there can be no doubt on this point in the case of my specimens, for the terminal claws show no more than a fine fringe along their whole length. Our species, therefore, is at all events not identical with the Queensland *C dubia.*

Now as already mentioned, Sars recorded *C. dubia* from New Zealand, and this record would bring the species into especial prominence as an instance of zoo-geographical relationships; but here again the essential point remains obscure, for Sars likewise had no male specimens. But the figure which he gives does not hint at any secondary crest, so that it may very well be possible for the Lake Lyndon form to be identical with that from Lake Wakatipu. It is interesting to note, in connection with the relationships of the Australian-New Zealand faunas with that of South America, that Sars drew a comparison between his form and the var. *acuminata* of *C. dubia,* described by Ekman from Patagonia; but once again, Ekman saw no males of his form. And moreover, generally speaking, the attempts hitherto to characterize the species of Cladocera are to a considerable extent of doubtful systematic value. I might instance, as a characteristic of the form from Lake Lyndon, the size of the eyes, which are considerably larger than those of Sars's form from Lake Wakatipu, or of Ekman's from Patagonia. But in view of what is known of the variability of the size of the eyes according to environmental circumstances, I would prefer to consider this character as a minor difference only. Certainly the circumstance that my specimens came from a considerable altitude, and were therefore exposed to more intense ultra-violet light, permits us to conjecture that the eyes are influenced by the light-relationships in Lake Lyndon; and this suspicion gains strength from the fact that it was observed, in the neighbourhood of the Biological Station at Lunz, that *Daphnias* from mountain-pools at an elevation of more than 1,600 metres had larger eyes than those from the bottoms of the valleys.

Another character might perhaps serve better as a distinguishing feature between this and the other forms, viz., the strong development of the process from which arises the lateral seta of the antennule.

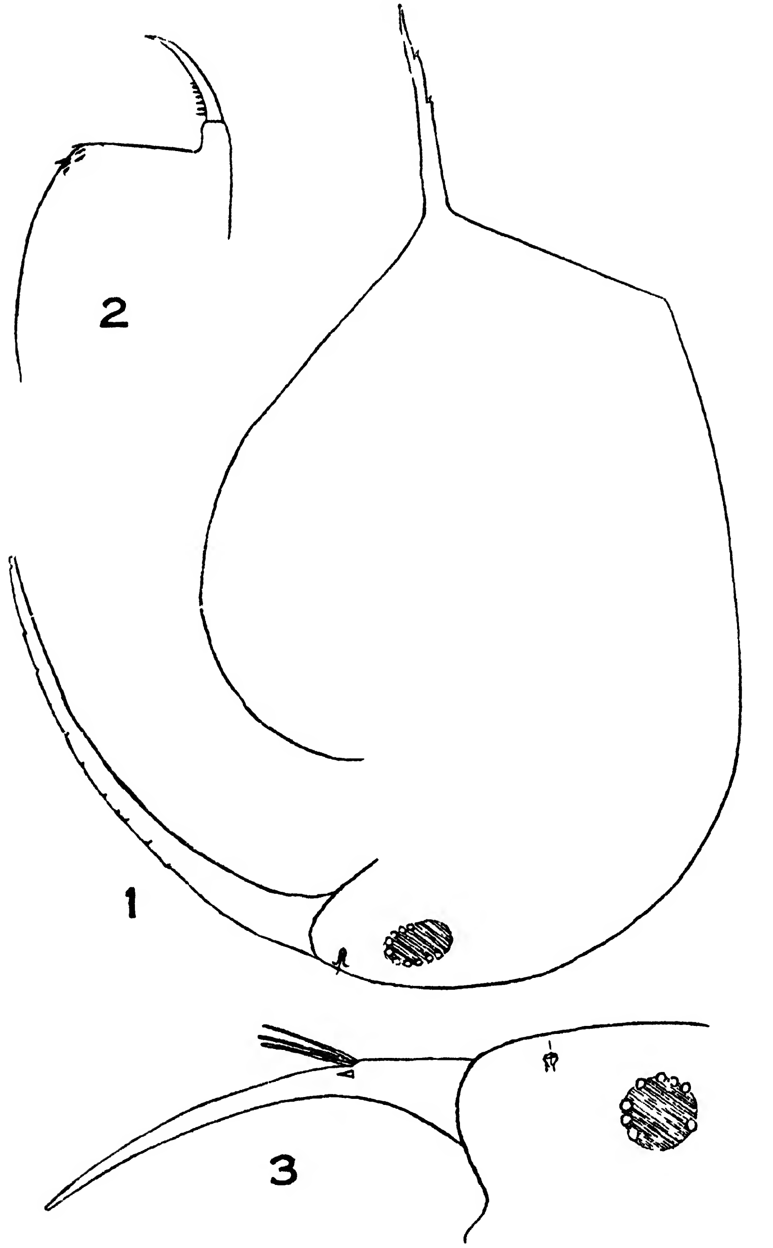
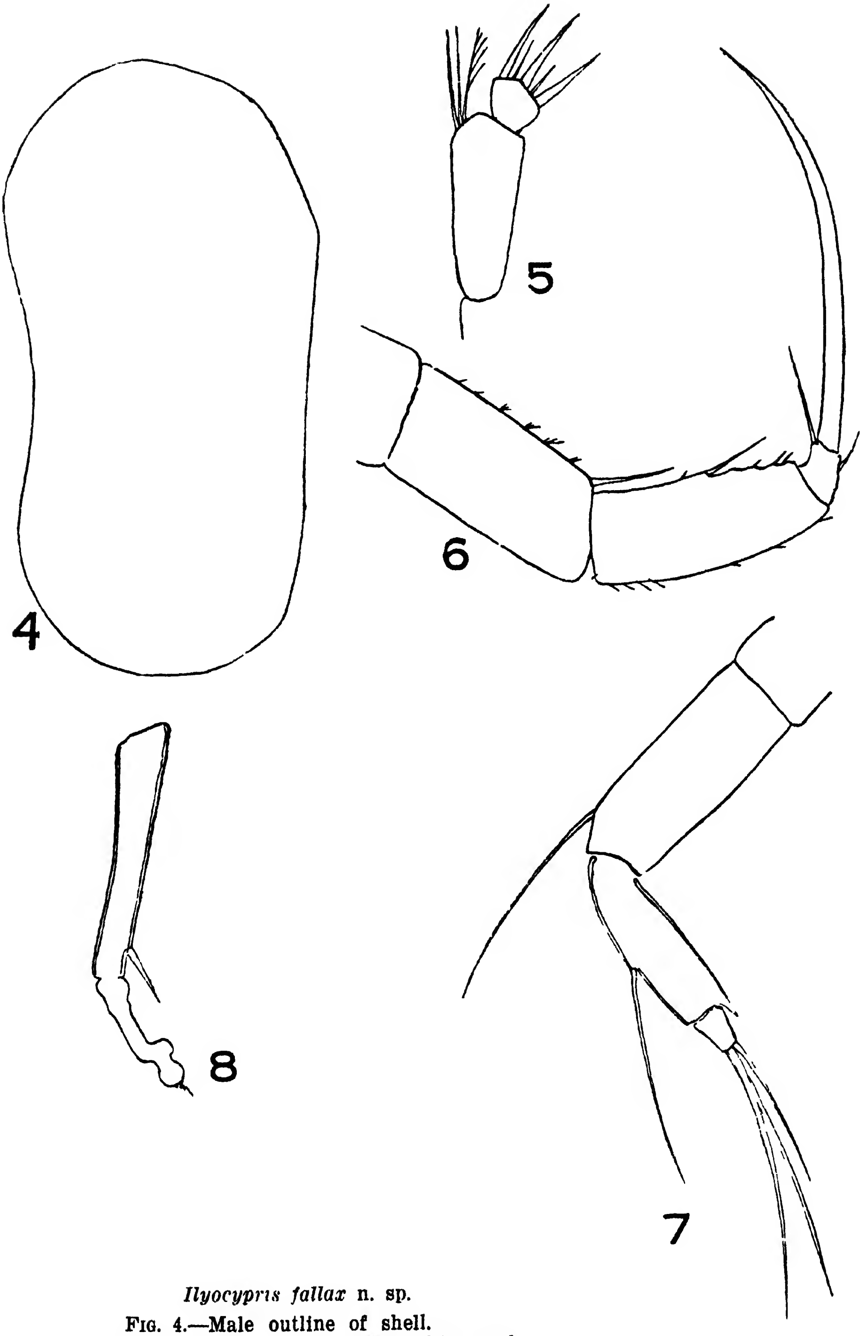


FIG. 1.—*Bosmina hagmanni* Stingelin, young female with incisures on the antennule and mucro.
FIG. 2.—*Bosmina hagmanni* Stingelin, post-abdomen of mature female.
FIG. 3.—*Bosmina hagmanni* Stingelin, head of a female with two embryos, antennule without incisures.

Under these circumstances there is no alternative but to consider the *Ceriodaphnia* of Lake Lyndon as perhaps belonging to *C. dubia*, and to leave the question undecided until the males of the species can be investigated.

Bosmina hagmanni Stingelin.—Before explaining the reasons for the assigning of this form to the South American species *B. hagmanni*, it will be necessary to refer briefly to previous references to Australian Bosminidae. While *Bosmina* appears to be very sparingly represented on the Australian continent—there are only two records of the occurrence of *B. longirostris*, and none was noticed by Henry in her work on the Cladocera of New South Wales—yet in 1909 G. W. Smith made known three new species from Tasmania, which, after a minor nomenclatural alteration, have gone down in the literature as *B. Goffreyi*, *B. Sorelli*, and *B. tasmanica*. However, Ruehe has since expressed strong doubts, in his valuable monograph of the genus *Bosmina* (*Zoologica*, Heft 63, 1921) upon the specific distinctness of these forms. Sars, again, in his "Pacifische Plankton-Crustacean" (*Zool Jahrb.*, Bd. 19, 1903), has described B. *meridionalis* from Lake Wakatipu in New Zealand; but here also, Ruehe, in the above-mentioned monograph, has raised serious doubts as to the validity of this species; for he points out that, as may be seen both from the author's description and from his figures, Sars's species falls into the "*longispina* series" of *B. coregoni*, and that Sars (to translate Ruehe's remark) "perhaps came to his conclusion through the incorrect assumption that *B. meridionalis* was the only *Bosmina* from the southern hemisphere." We shall shortly see how justified Ruehe was in assuming this critical attitude, and on the other hand how unsafe it is to base a definite conclusion merely upon the description and figures of a species.

As the accompanying figures show (Figs. 1—3), the present species has a certain resemblance to *B. obtusirostris*. The frontal seta is generally inserted nearer to the end of the rostrum than to the eyes; but I also found specimens in which the frontal seta was inserted very nearly in the middle. The terminal claw of the hinder abdomen has no pronounced notch, and bears only seven thick spines, *which become smaller distally*. In well-grown and embryo-bearing females, averaging 0.5 mm. in length, the antennule showed no incisures, and the mucro was quite free from incisures. Of the "seta Kurzi" nothing was to be seen, so that this must be regarded as quite absent. There were no males or ephippigerous females; but numerous young specimens were present, which make it possible to identify the species with *B. hagmanni;* for they had not only 11 incisures on the antennule, but also *two* sharp incisures, each armed with a spine, on the mucro, on its dorsal side. To make use of this discovery for our present purposes, it may be recalled that in a later comment upon Ruehe's discussion (on p. 18 of the above-mentioned monograph), I have shown that in *B. hagmanni*, described by Stingelin from the Amazon, we have a typically South American form, whose distribution extends somewhat into North America, but, as far as we know, does not reach the older world (cf. Brehm, Ergebnisse einer von Prof. Klute nach Patagonien unternommenen Forschungsreise, *Archiv. f. Hydrobiologie*, 1925). In this paper I have



Ilyocypris fallax n. sp.

FIG. 4.—Male outline of shell.
FIG. 5.—Terminal joint of maxillary palp.
FIG. 6.—Male, first leg.
FIG. 7.—Male, second leg.
FIG. 8.—Grasping organ of male.

also pointed out that the dorsal position of the incisure of the mucro, and consequently the identity of the species, are often obscured by the fact that this character is shown in young specimens, and is lost in the sexually-mature stage; so that the specific identity can be definitely determined only if, as in the present collection from New Zealand, young specimens also occur with the adult ones. This is perhaps an exceptional case, but it is not without parallel; for in many Chironomidae we can detect specific differences in the larva or pupa where none are to be recognized in the imago.

There is no doubt, then, of the identity of the *Bosmina* from Lake Lyndon with the South American species; and I am convinced that in an adequate revision, all the other supposed species mentioned above from the Australian and New Zealand regions will be found to belong to the one form *B. hagmanni.*

In that case the opinion expressed by Smith as to the origin of the Australian *Bosminas* may be allowed to pass, if it is understood in a different sense from that in which the author intended it. In a footnote on page 14 of his monograph, Ruehe expresses his opinion of the new species proposed by Smith:—"Infolgedessen stehen auch die weitgehenden tiergeographischen Speculationen, soweit sie Smith auf das Vorkommen von Bosminen in Tasmanien gründet, auf sehr schwachen Füssen. Smith glaubt annehmen zu müssen dass Bosmina (!) von der nördlichen Hemisphäre uber die Andenkette und eine antarktische Landbrücke nach Tasmanien gelangt sei." (Hence the sweeping speculations concerning zoogeography, in so far as Smith bases them on the presence of *Bosmina* in Tasmania, are very insecurely founded. Smith thinks it necessary to assume that *Bosmina* has spread from the northern hemisphere into Tasmania by way of the Andes and an Antarctic land-bridge.)

From Ruehe's parenthetical exclamation mark, it may be seen how improbably he considered the whole hypothesis. And yet it seems to me quite reasonable, so long as we restrict it to the route by which *B. hagmanni* reached Australia; but the species may very well have originated in South America, and the representatives found north of Panama seem to me to be quite as much emigrants as the Australian. But it seems also reasonably safe to suppose that originally the genus *Bosmina,* as such, was derived from the northern hemisphere, in accordance with Smith's map of the geographical distribution of the genus.

3. Ostracoda from Banks Peninsula.

The specimens referred to here were collected near Motukurara, on the flat below Gebbies Pass; they were in a shallow muddy pool under a culvert on the main road.

In this collection (tube 34), which is characterized by the great abundance of *Newnhamia fenestrata* and *Cypridopsis* cf. *aculeata,* a member of the genus *Ilyocypris* was found; unfortunately there was no more than the one specimen, a male. It is recorded below as *Ilyocypris fallax* n. sp. (Figs. 4—11.)

Hitherto no species of *Ilyocypris* has been known from New Zealand. In 1899 Sars recorded a species of the genus from Queens-

land, under the name *I. australiensis*; but unfortunately the description of the species is so imperfect that Mueller, in his monograph in the "Tierreich," considered it to be only a *nomen nudum*. Until further material from the same locality can be examined in order to revise the description, one can hardly arrive at a working-idea of the nature of the species. Henry has mentioned *I. australiensis* in her paper, but as she had no specimens of the species she could give

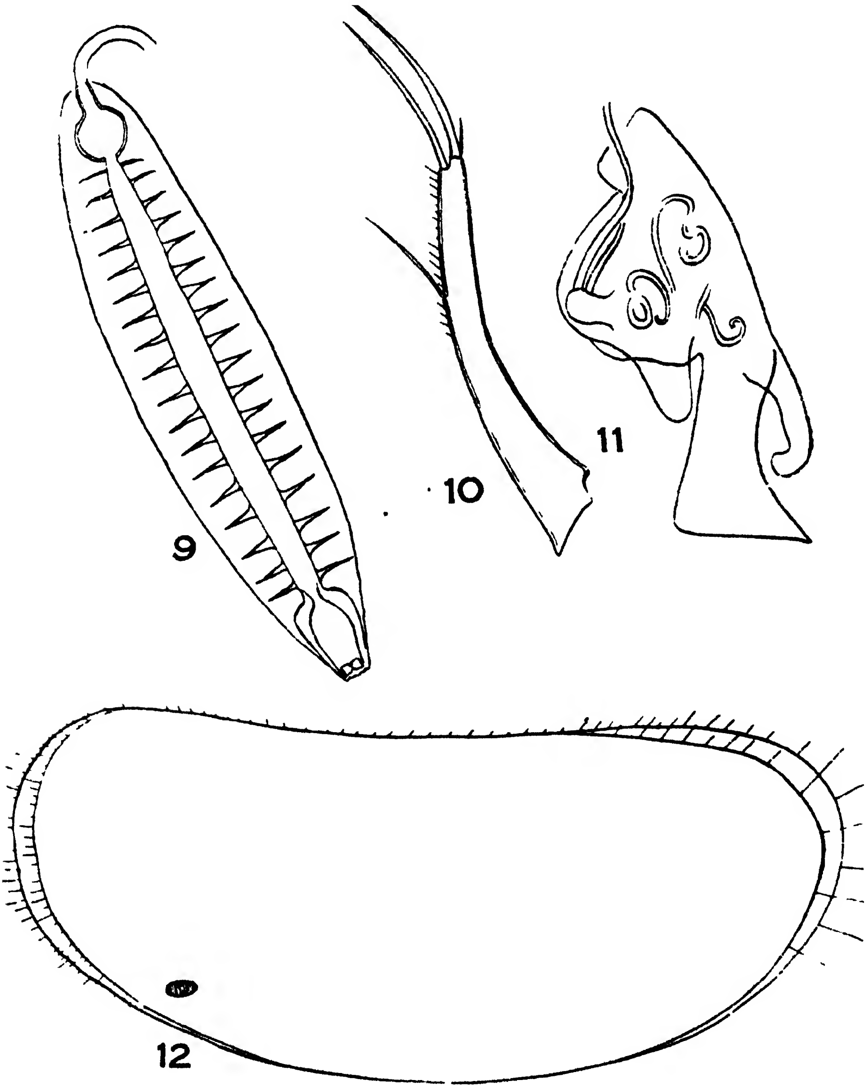


FIG. 9.—*Ilyocypris fallax* n. sp., Zenker's organ.
FIG. 10.—*Ilyocypris fallax* n. sp., furca of male.
FIG. 11.—*Ilyocypris fallax* n. sp., copulatory organ of male.
FIG. 12.—*Herpetocypris Pascheri* n. sp., outline of shell.

no further information, so that it would have been better if she had followed Mueller in ignoring the specific name and retaining only the record of the genus from Australia.

My New Zealand specimen of this genus is a male, 0.96 mm. in length, whose valves are covered with numerous colonies of a jet-black *Siderocapsa*. In general appearance the animal has such a a resemblance to a *Limnicythere*, especially in the outline and colour of the shell, that at first glance I thought that I had a representative of that genus before me; and for this reason the specific name *fallax* was chosen. The granulations frequently found on the valves of *Ilyocypris* do not occur in the present form. The swimming-setae reach beyond the claws. In comparison with figure of *I. gibba* given by Vavra, the small lateral tufts of setae, which occur especially on the middle joints of the second antennae and on the cleaning-foot, are much less developed, and are more noticeable on the first pair of feet, of which unfortunately Vavra gives no figure. As for the modified antenna of the male, I have before me a figure of *I. decipiens* by Alm, and from this the New Zealand species differs considerably. The end-joint in our species is not pointed, but ends in two semi-circular swellings. Instead of the plumed seta on the fingered process, there is here a different structure, which however was difficult to see clearly, as it was obscured in the preparation. Five small and slender hyaline setae could be made out, or else a hyaline lamella, frayed out along the edge. In the Zenker's organ, the entrant and exit apertures have the spherical form characteristic of the genus, and the organ is provided with 18 rings of spines. The furca is strongly bent. The proximal edge of the furcal branch is quite bare, which is to be noted, because Vavra shows three tufts of hairs near the base of *I. gibba*. The hinder edge bears long thin hairs between the terminal claw and the seta of the hinder edge, while in front of the seta of the hinder edge there are only a few hairs, and these are immediately in front of it. The copulatory organ shows the typical characters in the genus.

4. Notice of the Occurrence of *Saycia* in New Zealand.

In a tube bearing the label, "stagnant grassy pond, just north of Waimate," two female specimens of the Cladoceran *Saycia orbicularis* G. O. Sars were found; this species has hitherto been known only from Victoria, and is evidently rare on the continent. It was not found by Henry in New South Wales, and in view of the size and conspicuousness of the species, this can hardly be put down to an oversight.

5. **Herpetocypris Pascheri** n. sp. (Figs. 12—19.)

In a tube whose label unfortunately was destroyed, there occurred, together with numerous examples of a blue-green *Cypretta*, some specimens of a large Ostracod, which is described below as *Herpetocypris Pascheri* n. sp.

Before we enter upon this description, however, an interesting point may be noted in connection with the *Cypretta* just mentioned.

In his paper, "Contributions to the Knowledge of the Fresh-water Crustacea of New Zealand" (*Videnskabs Selskabets Skrifter*, Kristiana, 1894), G. O. Sars includes three plates of coloured figures of the Ostracoda described by him, and it is very noticeable that with the exception of *Cypris sydneia*, all the species are coloured more or less green. At first I regarded this as a coincidence, but after seeing Mr. Bennett's material I must state that the New Zealand Ostracod fauna is in fact distinguished by an extraordinarily high percentage of green species. In the present state of ignorance of the nature of this green pigment, one must perforce refrain from any attempt to explain this phenomenon. *Herpetocypris Pascheri* is likewise green in colour, though the pigment is not equally intense in all specimens. Examples from another tube, which bore the locality-label, "shallow muddy pool, probably temporary, under a culvert, Cheviot," were distinguished by an intensely green colour.

The present form is placed in the genus *Herpetocypris* because the left valve of the shell is larger than the right, by which it is distinguished from *Candonocypris*, and because the seta of the hinder edge of the furca is not definitely clawed, as in *Iliodromus*; yet it has not the character of a simple seta, but it somewhat intermediate, so that in considering the position of the species, one might well be in doubt whether to regard it as an *Iliodromus* or a *Herpetocypris*.

As may be seen from the accompanying figures, *Herpetocypris Pascheri* is characterized by the following features:—At the end of the second antenna, there is a structure at the end of the last joint which may be best described as a group of flatly arranged setae. In the literature which I have consulted, I find a similar structure figured by G. W. Mueller in his species *Cypris bicornis* which he described from South Africa (*Zool. Jahrb.* Bd. 13, 1900). The penultimate joint of the second antenna bears a comb of spines immediately in front of the point of insertion of the seta which is placed in the middle of the lateral margin. The swimming setae reach nearly to the end of the claws. The respiratory plate of the mandible bears five setae. The second joint of the mandibular appendage bears a transversely oblique row of short setae on the surface. Both of the strong claws of the masticatory lobe of the maxilla are toothed. The basal joints of the first pair of legs bear short tufts of setae at the edge; the brush-foot shows the typical form for *Herpetocypris*, that is, in particular, a terminal claw which is at least three times as long as the end joint. The foremost seta of the furca bears five fringes of teeth; the distal fringes are always more strongly developed than the preceding. These fringes remind one somewhat of the arrangement in *Stenocypris*, but the asymmetry of the branches of the furcae, characteristic of that genus, is lacking; this is at least indicated in some Asiatic species of *Herpetocypris*. The seta of the hinder edge, which, as mentioned above, is intermediate between a simple seta and a claw, is situated immediately alongside the shorter terminal claw. The anterior seta of the furca is about as long as the shorter claw. The accompanying figures indicate the outline of the valves and the structure of their edges. The available specimens represent only the female sex, and this gives rise to the suspicion that the species may be obligatorily parthenogenetic, especially as no

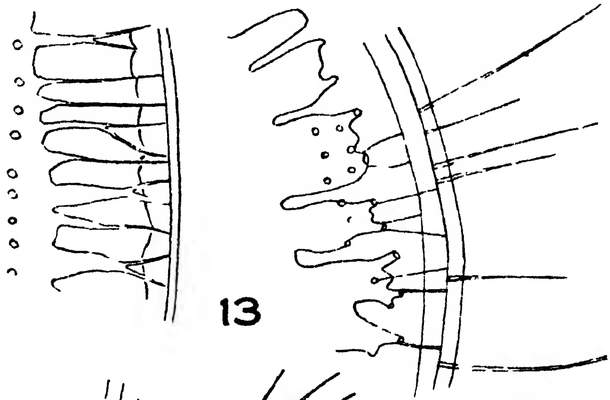


Fig 13.—*Herpetocypris Pascheri* n. sp, structure of edge of shell.
Fig. 15.—*Herpetocypris Pascheri* n. sp., palp of mandible.

sperms were to be found in the receptacula of the females. The length of the animal averaged 2.5 mm.

I dedicate this new species to my honoured friend Professor A. Pascher, to whom authors of the *Suesswasserflora Deutschlands, Oesterreichs, und der Schweiz* are indebted for his investigations into the phylogeny of the Algae and Rhizopoda.

6. **Camptocercus** sp. (Figs. 20, 21.)

In a tube which unfortunately bore no locality-label, I found an example of a *Camptocercus,* whose specific identity however may remain an open question because of the debatable details involved. This discovery provides at least the first record of the genus from New Zealand. The genus was already known from the Australian continent, for Sars has described a species *C. australis* from there; but the present species is not the same as that of Sars.

In the third volume of the *Wissenschaftliche Ergebnisse der Deutschen Zentral Africa Expedition* (Leipzig, Verlag Klinkhardt), I have described *C. adhaerens* from Lake Luhondo, and in this the presence of a grasping-organ in the neck region was recorded as an especially characteristic feature. In 1918, in his paper "Cladoceres des Andes Peruviennes," in the *Bullet. Soc. Neuchateloise des Sci. naturelles,* tom. 43, Delachaux again described a new species *C. naticochensis* which was characterized also by the possession of a similar grasping-organ. And since the present specimen from New Zealand likewise possesses this organ, I supposed at first that it would be necessary to assume that a primitive group of the genus *Camptocercus* was thereby indicated, the group being characterized by the possession of a grasping organ, and restricted in its distribution to the southern hemisphere.

A remark by Wagler, however, in his account of the Cladocera in Kuekenthal's *Handbuch der Zoologie,* suggested that this organ might be present in all species of *Camptocercus.* Unfortunately when I described *C. adhaerens* I had no material for comparison, by which I might have been able to answer the question whether the grasping organ is present in all or only in some of the species of *Camptocercus*; nor have I any such material at the present time, and the available literature contains nothing which might solve the problem. I therefore referred to Dr. E. Wagler, who was kind enough to inform me that the European species also possess this organ. It is therefore very probable that the organ is a generic character, and that the attempt by Delachaux and myself to separate a group of phylogenetically older species, restricted to the southern hemisphere, from a phylogenetically younger group of species, limited to the northern, is left without foundation.

It therefore remains an open question whether the two species founded by Delachaux and by myself should be withdrawn, or whether in spite of the lack of phylogenetic and zoo-geographical distinctiveness they may be retained. The fate of the present species from New Zealand is linked up with that of the other two. Before the question can be settled, however, light must be thrown on the problem whether the characters used in the description of these

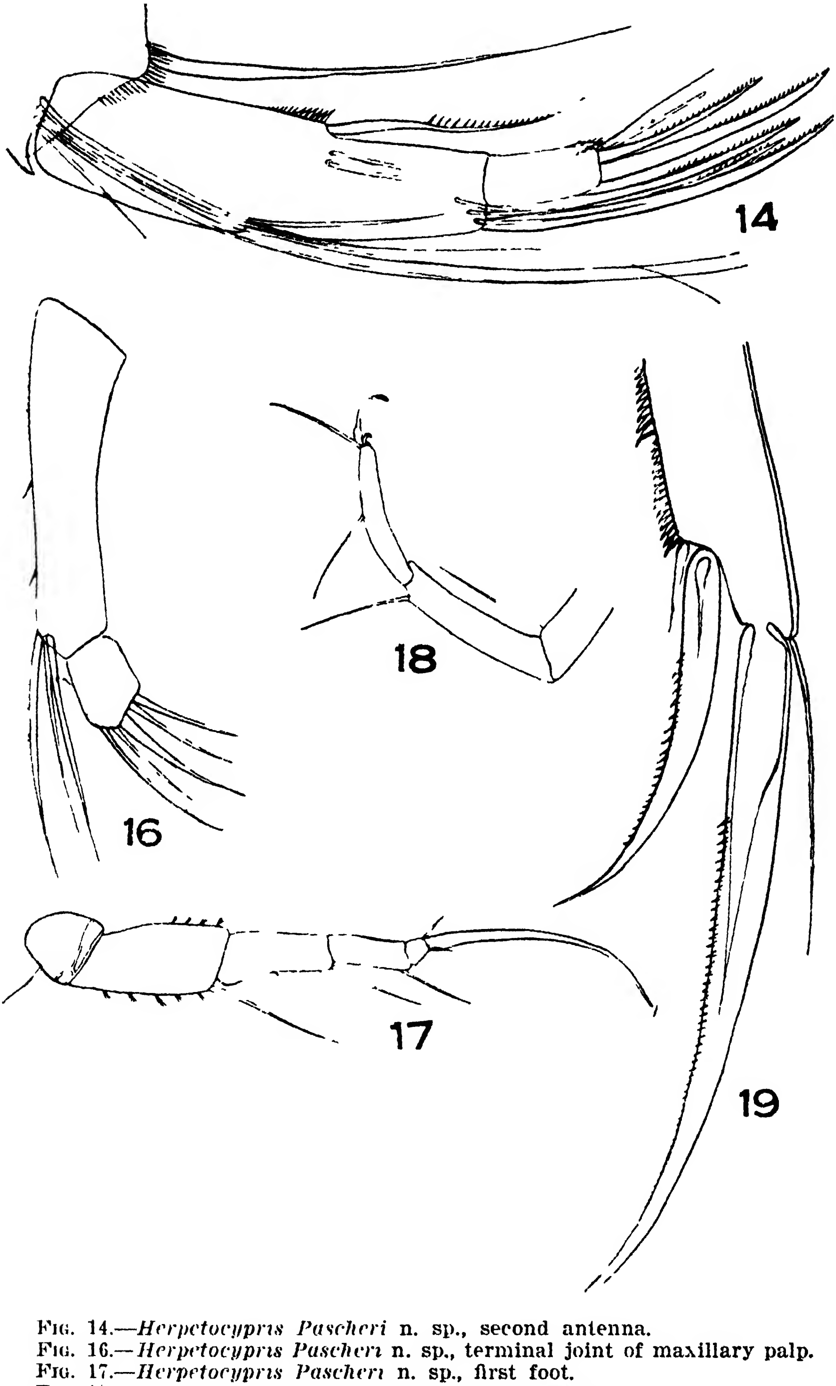
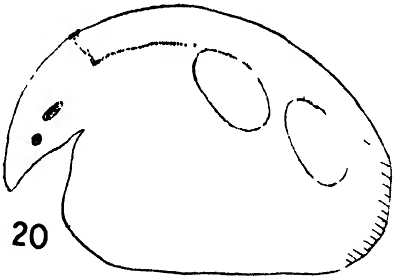


Fig. 14.—*Herpetocypris Pascheri* n. sp., second antenna.
Fig. 16.—*Herpetocypris Pascheri* n. sp., terminal joint of maxillary palp.
Fig. 17.—*Herpetocypris Pascheri* n. sp., first foot.
Fig. 18.—*Herpetocypris Pascheri* n. sp., second foot.
Fig. 19.—*Herpetocypris Pascheri* n. sp., end of furca.

species do in reality possess the distinctiveness attributed to them as structures of genuine systematic worth. It is known to all students of the Cladocera that there reigns a regrettable obscurity on this point, and that the use of such features involves a highly subjective factor. I believe that those who write on the Cladocera arrive, either conscious of the fact or not, at conclusions which differ according as the authors in question consider the Cladocera to be cosmopolitan or otherwise. Those who are of the opinion that different regions must be inhabited by different Cladocera will naturally find characters sufficient for the distinction of species in such features as the number of teeth or lateral tufts of hairs on the hinder abdomen, in the sculpture of the valves, in the form of the carina, or in the size of the eyes. But one who, like the author of the present paper, finds in the Cladocera a group which, generally speaking, is cosmopolitan in its distribution, will remain somewhat sceptical of the value of these features; and all the more so, because with many of these characters (such as the form of the carina in *Acroperus*, and the size of the eyes in *Simocephalus* and *Daphnia*), it has been found that environmental circumstances, both in nature and in experiments, have a profound influence.

If after these precautionary remarks we review the three problematical species, we find the following characters, apart from the grasping-organ:—

In *C. adhaerens*, the eye is twice as large as the pigmented area; on the post-abdominal edge there are 18 teeth (up to 17 in *C. longirostris*, and at least 20 in *C. macrurus*). There is also the longitudinal striping of the valves and the granulation of the carina.



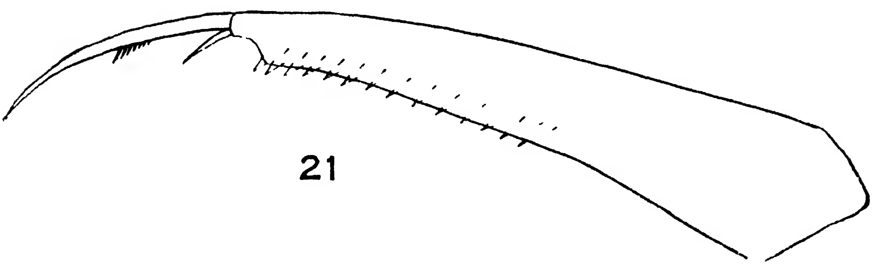


FIG. 20.—*Camptocercus* sp. (*atavus* in litteris).
FIG. 21.—*Camptocercus* sp. (*atavus* in litteris).

In *C. naticochensis,* the reduction of the keel of the head and of the dorsal surface was quoted as typical; but this feature is not surprising, for on acocunt of the altitude of the locality (Lake Naticocha lies at a height of more than 5,000 metres), such a reduction in the carina is equally to be expected as in the case of the *Acroperus* of the Alpine lakes of Europe, or of *G. aloniceps,* which was described by Ekman from Patagonia, and which forms a remarkable parallel to the *Acroperus* of Europe. In *C. naticochensis* the number of post-abdominal teeth is 18-19, that of the lateral tufts of setae is 15. The eyes and the pigmented area are large (this largeness of the eyes can also be associated with the altitude of the home of the species, as found also in the case of the eyes of *Daphnia pulex* from the lakes in the vicinity of Lunz). •

Finally, in the New Zealand form, which, in accordance with the earlier speculations discussed above, I had intended to name *C. atavus,* the following features suggest themselves as distinctive:—16 post-abdominal teeth, reduction of the lateral tufts of setae on the post-abdomen to single setae, the strong developement of the carina, the elongated form of the eyes (which are twice as long as broad), and finally the fact that the post-abdomen, in front of the long terminal claw, is suddenly narrowed, with a distinct marginal angulation, whereas in *C. adhaerens* and *C. naticochensis* it gradually diminishes right to the whole breadth of the terminal claw. The length of the two perfectly hyaline egg-bearing females from New Zealand was 1 mm.

To summarize our investigations—with the exclusion of the question of the grasping-organ—we find that *Camptocercus* is represented both in Australia and in New Zealand; the Australian species, *C. australis* Sars, differs from the New Zealand form by its smaller size (0.7 mm. as against 1 mm.) by the steady diminution of the post-abdomen, by the greater number of post-abdominal teeth (22 as against 16), and finally by the non-elongated form of the eyes.

On the assumption, which has yet to be proved, that these characters will suffice to distinguish the species, *C. australis* would stand as the Australian representative of the genus, and *C. atavus* as the New Zealand representative. Yet I still entertain doubts as to the validity of the latter species, and believe that in this genus—just as shown by the younger Spandl in the case of *Alona*—many species from beyond Europe will prove to be identical with the European species, since most of them were founded under the impression that different regions must be inhabited by different species. In this connection it has to be stated that the Cladocera are for the most part cosmopolitan, and also that the unique character of the Australian region in zoo-geographical respects, which is also clearly recognizable in other groups, finds expression here in the presence of three endemic genera, *Saycia, Neothrix,* and *Pseudomoina.*

Fresh-water Fauna of New Zealand.

NOS. 7–8.

By DR. V. BREHM, Biological Station, Lunz, Austria.
(Communicated by E. W. BENNETT).

7. ON A NEW BOECKELLID FROM LAKE LYNDON.

IN the account of the fauna of Lake Lyndon, at p. 793 the occurrence of a *Boeckella* and of *Bosmina hagmanni* was recorded. The former was not further discussed, as I understood at the time that Mr. Bennett wished to deal with the members of this group. As, however, he has written to say that he does not intend to discuss any of the Lake Lyndon material, a description is here given of the new *Boeckella* from that locality; and the opportunity is also taken of reverting to the problems connected with the occurrence of *Bosmina* in the southern hemisphere, a matter which was also discussed in the former paper.

Boeckella hamata n. sp.

The *Boeckella* from Lake Lyndon is one of the small species of the genus, for the male is only 1.2 mm. and the female only 1.5 mm. long. The last thoracic segment of the female is produced into a long double lobe, whose outer and longer tip reaches almost to the end of the genital segment (Fig. 1). The antenna of the female does not reach right to the end of the furca. The fifth pair of feet is distinguished by having seven setae on the terminal joint of the outer branch. The inner branch is usually three-jointed, yet I found

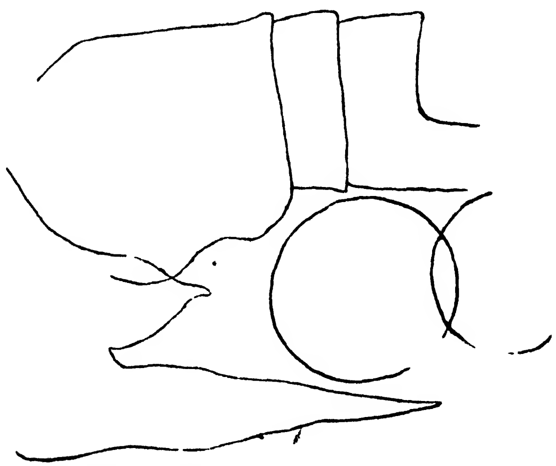


FIG. 1.—*Boeckella hamata* n. sp. Thoracic lobes of egg-bearing female, lateral view.

in the same collection some egg-bearing specimens in which an articulation between the last and the penultimate segment of the inner branch was only indistinctly visible, or not at all; so that my attention was again forcibly drawn to the fact that the number of joints in the appendages is of trivial importance.

The structure of the modified male antenna is indicated by the accompanying figure (Fig. 2). In the fifth feet of the male (Fig. 3), both of the inner branches are one-jointed, and the second segment of the basal section of the left foot is neither toothed nor provided with a denticulate lamella. Since, moreover, the endopodite of the left fifth foot is shortened, this species would fall into group 16 of

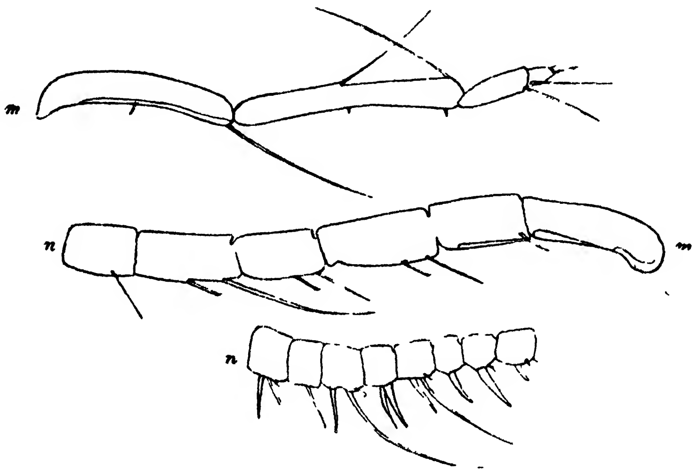


FIG 2.—*Boeckella hamata* n. sp. Outer portion of modified male antenna, represented in sections; *m – m* and *n – n*, corresponding points.

the subdivisions given by Marsh* in his artificial key for identification. This group includes *B. rubra* Smith and *B. robusta* Sars, of which the former is known from Tasmania and the latter from Australia. The *Boeckella* from Lake Lyndon, however, is not identical with either of these, and in spite of a certain resemblance to *B. robusta* constitutes a new species, which is especially distinguished by the structure of the fifth feet of the male (Fig. 3). Characteristic features of the left fifth foot of our species are:—(1) the inner branch is extremely short, but stouter (according to the figure given by Marsh) than that of *B. robusta;* (2) the end-claw is suddenly narrowed through approximately the last sixth of its length, so that in shape it reminds one of the end of the body of certain male Nematode worms, such as *Oncholaimus*. The right fifth foot shows more remarkable differences. The inner branch is not as narrow at the end as in *B. robusta*, but rounded, and furnished with a small latero-terminal

*A Synopsis of the species of *Boeckella* and *Pseudoboeckella*, etc.—*Proc. U.S Nat. Mus.*, vol. 64.

point. The basal inner edge of the inner branch is produced into a long, pointed and hook-shaped process, on account of which the name *hamata* was chosen for the species. In the first joint of the outer

FIG. 3.—*Boeckella hamata* n. sp. Fifth feet of male; *a*, left foot; *b*, right.

branch, the distal spine of the outer edge is longer than in *B. robusta*. The terminal claw bears basally, on the inner edge, a very small but nevertheless remarkable chitinous knob, and opposite this arises a chitinous lamella, which extends out obliquely and distinctly beyond the contour of the claw (Figs. 3b, 4). The end of the claw is suddenly narrowed, as described for the other foot.

FIG. 4.—*Boeckella hamata* n. sp. Oblique view of terminal claw, whose basal part appears from this aspect to be broadened by the chitinous lamella.

If a phylogenetic comparison with *B. robusta* may be ventured upon, one may perhaps recognise in the New Zealand *B. hamata* a more primitive form, because in *B. robusta* the hook-shaped process on the basal inner edge on the inner branch of the right foot is reduced to a "short curved spine."

In the material examined, the *Boeckella* was abundantly represented by both sexes, but immature forms predominated over the sexually mature.

8. **Bosmina hagmanni, some further remarks on.**

As mentioned in the previous account of the plankton fauna of Lake Lyndon, abundant representatives of a *Bosmina* were present in the collections, and an investigation of this form led me to refer them to *B. hagmanni;* from the point of view of geographical distribution this is a result of some interest, for this species was previously regarded as a South American form. I also expressed the opinion on that occasion that Sars' *B. meridionalis,* described from Lake Wakatipu, New Zealand, might also belong to *B. hagmanni.* But another opinion as to the status of *B. meridionalis* has recently been given in a work which, unfortunately, I was unable to consult when writing my previous account; and this opens up the problem of *Bosmina* once more, and does so from a viewpoint which is in part a new one.

Burckhardt, in pt. 3 (Bosminidae) of his work on the zooplankton of the lakes of eastern and southern Asia,* has described a new *Bosmina* from China as *B. fatalis,* which is known with certainty only from the male, this circumstance providing the specific name bestowed upon it. Burckhardt's account (to translate his words) states that " of all the *Bosminas* known to me, none agrees as closely with *B. fatalis* as does the New Zealand *B. meridionalis* Sars. But neither Sars nor Brady found males of this species. . . ." There are in fact two gaps in our knowledge, which must be filled before this matter can be cleared up satisfactorily; in Burckhardt's account I find nothing concerning the position of the incisures on the mucro of *B. fatalis,* and to the present date the males of the New Zealand *B. meridionalis* remain unknown. There are thus two possibilities in attempting to assign the New Zealand form to its systematic position; the males are either of the *fatalis* type, or they are of the *coregoni* type. Similarly, two possibilities present themselves in the case of Burckhardt's *B. fatalis;* this species has either dorsal or ventral incisures. These possibilities may be separately considered under the following four heads:—

(1) If *B. fatalis* has ventral incisures on the mucro, Burckhardt's interpretation remains unchanged;

(2) If *B. fatalis* has dorsal incisures, I would have to regard it as being the same as *B. hagmanni.* Since, however, I consider that this case may be excluded, I do not discuss it further here; the *punctum saliens* in this question arises again in connection with the fourth possibility below.

(3) If *B. hagmanni* has males of the *B. coregoni* type, the views which I have previously expressed concerning *B. hagmanni* remain unaltered.

(4) But if *B. hagmanni* has males of the *fatalis* type, I would regard the latter as *B. hagmanni;* and in my opinion it would then only remain to be determined whether all the collections of *B. hagmanni* have males of the *fatalis* type, or whether some have males of the *fatalis* type and other *coregoni* type; in other words, whether *B. hagmanni* is a general name including more than one species, these

---

**Revue d'Hydrobiologie*, vol. 2, Aaru (Switzerland), 1924.

species differing from one another in the structure of the male. From this viewpoint, the whole position, as far as the systematic nomenclature is concerned, depends on whether, in our attempts to distinguish species, we should attach chief importance to the incisures on the mucro, or whether we should rather stress the structure of the male abdomen. If any weight can be attached to a character which is ordinarily to be regarded as of subsidiary importance only, I would refer to the very characteristic geographical distribution of those *Bosminas* with dorsal incisures; for as far as is known at present, their distribution coincides with that of the Boeckellids, or perhaps more precisely with that of the marsupials, for *Bosminas* of the *hagmanni* type have hitherto been known from Australia and South America, but not from Africa. It appears then to me that the *Bosminas* with dorsal incisures on the mucro may constitute a group

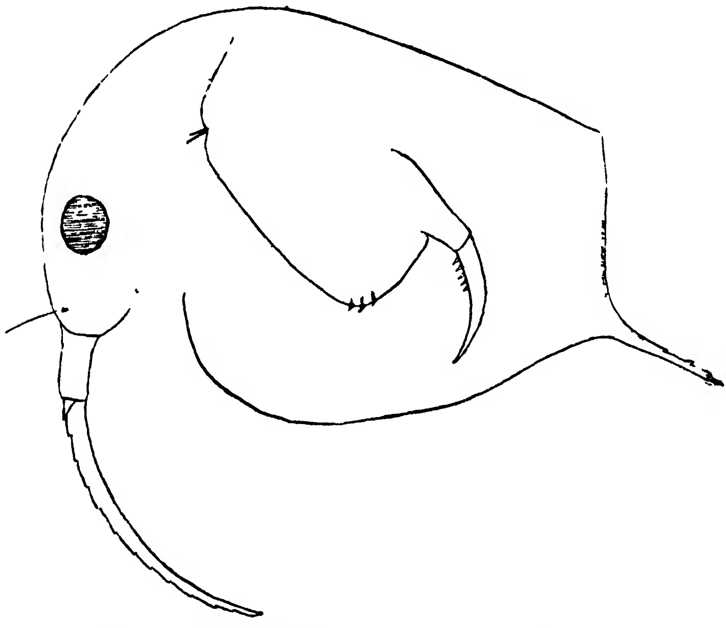


FIG. 5.—*Bosmina hagmanni* from Lake Lyndon. Outline of a young female, illustrating the dorsal incisures on the mucro. Abdomen shown on a larger scale, within the outline.

characteristic of the southern hemisphere, and that in contrast with these, the forms with ventral incisures belong to the northern hemisphere. According to Burckhardt, there are then three northern-hemisphere species, *B. coregoni*, *B. fatalis*, and *B. longirostris*, which are in part further subdivided into subspecies. Whether the *Bosminas* of the southern hemisphere are similarly subdivided, and have likewise become differentiated into several species, will be known only when a sufficient number of collections of *B. hagmanni* from southern sources have been investigated.

As the literature on this subject is very scattered, and the problems here discussed are, no doubt, thereby made more difficult for Australian and New Zealand zoologists, it may be worth quoting in this place the chief characters of the various types of *Bosmina*. The young female which is figured here also illustrates certain points; it shows distinct dorsal incisures on the mucro (Fig. 5), and the two figures of the abdomen (Fig. 6) illustrate the remarkable differences in the contour of the anal region in the males of the *coregoni* and *fatalis* types respectively. Unfortunately, Burckhardt's figure has been indistinctly reproduced, so that the copy given here (Fig. 6*b*) no doubt contains some imperfections, though not such as to disguise the essential differences in question. The abdomen of the male of *B. longirostris* is very similar in outline to that of *B. fatalis*, but (as

Fig. 6.—*Bosmina hagmanni*, abdomens of males; *a*, of *B. coregoni*; *b*, of *B. fatalis*.

indicated in the artificial key below) lacks the teeth found in that species. It is hoped that the reproduction of these figures may draw the attention of zoologists in the southern hemisphere to this matter, and that they will investigate anew at least the structure of the mucro and the form of the male in any collections of *Bosmina* available to them. And if some of the material from South America which the author hopes to discuss shortly in another article contains the requisite specimens for the elucidation of the problem, it will then become clear whether the systematic separation of these forms, as indicated in the following key, is justifiable. The key is a combination of Burckhardt's statements and my own, and I believe that it best indicates the present position of the systematics of *Bosmina*.

- I. Mucro with dorsal incisures.
  Southern Hemispere form — *B. hagmanni* Stringelin.
- II. Mucro with ventral incisures.
  Predominant form of the northern hemisphere.
  - A. Terminal claw of the male unarmed — *B longirostris.*
  - B. Terminal claw of the male provided with a row of spinelets.
    - a. Abdomen of the male suddenly narrowed in front of the terminal claw — *B. fatalis* Burckhardt.
    - b. Abdomen gradually decreasing in thickness — *B. coregoni.*

A New Fresh-water Hydroid from Otago.

Cordylophora lacustris Allman var. *otagoensis* n. subsp.

By MARION L. FYFE, B.Sc., Otago University.

[*Read before the Otago Institute, 23rd October, 1928; received by Editor, 7th December, 1928; issued separately, 25th March, 1929.*]

CONTENTS.

INTRODUCTION AND CLASSIFICATION.

THE species described grows fairly abundantly in Tomahawk Lagoon, Dunedin, and was discovered early in March, 1926, by the Rev. Dr. J. E. Holloway of Otago University.

The thanks of the writer are due to Professor W. B. Benham and Dr. H. J. Finlay for their advice and assistance, and to Professor R. Speight, of Canterbury Museum, and Mr. G. H. Briggs, of Sydney University, for the loan of specimens.

The species is evidently a member of the family Cordylophoridae Finlay, which according to Farquhar's list of New Zealand hydroids (Farquhar, 1895) is represented in New Zealand by two species only—*Tubiclava rubra* Farquhar, 1894, and *Cordylophora* sp. Hamilton, 1883. Hilgendorf (1897) later identified a hydroid from the Dunedin wharf as *T. fruticosa* Allman, but Bale (1924) considers that Hilgendorf's species is probably identical with *T. rubra*.

Comparison with a specimen of *T. rubra* from Canterbury Museum shows that, as regards size and general appearance, the species from Tomahawk Lagoon superficially resembles *T. rubra* rather than *Cordylophora*. The detailed structure and the method of attachment of the gonosomes are, however, entirely different from those of *T. rubra*, but, when compared with Allman's descriptions and figures of gymnoblastic hydroids (Allman, 1871), show close agreement with *Cordylophora*, a genus which is considered by most authorities to be represented by the single widely distributed species *C. lacustris* Allman, and its more restricted local varieties. The form from Tomahawk Lagoon nevertheless shows sufficient differences from *C. lacustris* to rank as a definite subspecies, for which I now propose the name *Cordylophora lacustris* Allman subsp. *otagoensis* n. subsp.

The *Cordylophora* sp. of Farquhar's list (1895) was found by Hamilton (*loc. cit.*) in the Esk River near Napier, and doubtfully identified by him as *C. lacustris* Allman. Farquhar (1894) considered

it possibly identical with the Australian *C. whiteleggei* Lendenfeld, 1886, which Stechow (1912) has placed as a synonym of *C. lacustris*, or at the most as a possible variety of that species.

The species from Tomahawk is, as already indicated, somewhat different from the typical *C. lacustris*; but, since the description given by Hamilton (*loc. cit.*) of the Esk River form is very generalized and gives no information as to detail of structure, it is very probable that it is identical with the species described in the present paper.

In a recent paper Finlay (1928), in discussing the nomenclature of the Cordylophoridae, gives his opinion that the name "*C. fluviatilis* Hamilton" was definitely proposed for the Esk River (Petane) form by Hamilton in his paper of 1883. Now Hamilton merely states that,

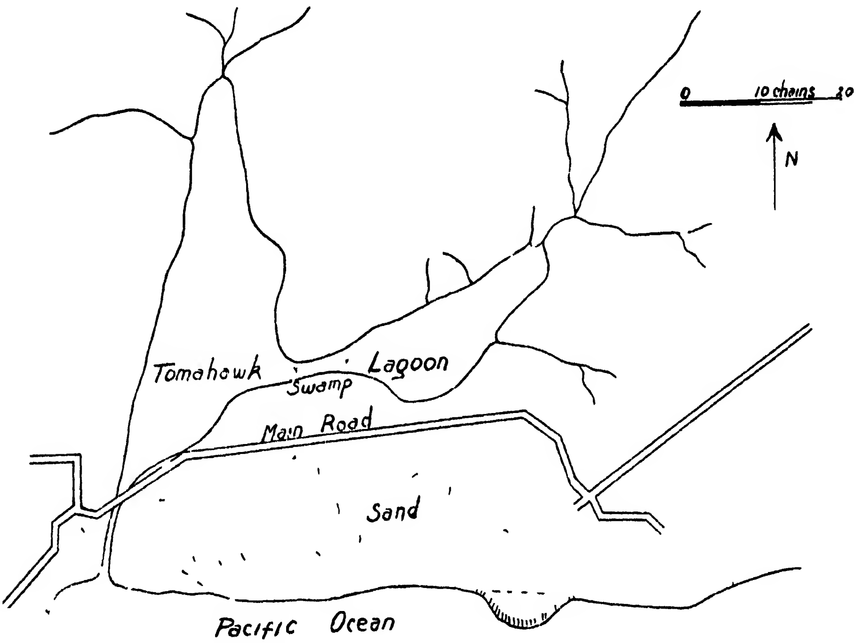


FIG. 1.—Map of Tomahawk Lagoon.

in view of the occurrence of the Petane hydroid in river and not in lake waters, *fluviatilis* would be a more appropriate name for the species, but at the same time he definitely identifies it with the European *C. lacustris*. To suggest that he proposed the name *C. fluviatilis* for the Esk River species, seems to the present writer to be stretching the facts a little too far, and in any case the absence of figures or any description of distinctive characters appears to be sufficient to invalidate his name. Since, on account of its previous indefinite standing, Finlay now proposes to validate Hamilton's name *fluviatilis*, the question arises as to whether, if *C. fluviatilis* Hamilton is invalid, *C. fluviatilis* Finlay may nevertheless still be substituted as a valid name. Here again, however, in the absence of detailed description, figures, or any information of diagnostic value other

than a statement of the locality of its occurrence, *C. fluviatilis* Finlay appears to the writer to rest upon only a very insecure foundation. Furthermore, the writer of the present paper has been unable to examine material from Petane, so that though the species from that locality is probably identical with that from Tomahawk Lagoon, identity has not been proved. Consequently it seems better to provide a new and definite name for the Tomahawk species, rather than to add to the confusion by applying to it either of the extremely doubtful name *C. fluviatilis.*

HABITAT.

Tomahawk Lagoon (see Fig. 1) is a shallow sheet of water consisting of two separate arms which communicate with one another by means of a narrow strip of almost stagnant swamp, bridged by a small culvert. The western arm opens into the sea by a narrow outlet, across the mouth of which drifting sand has accumulated as a bar through which the sea breaks only at abnormally high tides. The water in the outlet and in the western arm of the lagoon is therefore brackish, while in the eastern or upper branch it is quite fresh.

In every instance except one where the hydroid was collected, it was found attached to the stems of a sedge *Ruppia maritima*—not to the fresh green stems near the surface of the water, but to the blackened dead-looking stems at some small depth below the surface. This is probably due, not to any preference on the part of the hydroid for an old stem, but to the fact that the green *Ruppia* grows where there is a fair current of water, or floats on the surface in the sunlight, whereas the hydroid prefers a sheltered situation where the water moves slowly and the sunlight is not so bright. The hydroid was not found at all in the waters of the eastern arm, although a number of patches of *Ruppia* were observed there growing in shallow water; but in the almost stagnant fresh water beneath the culvert at the junction of the two arms, it was found in small quantity attached not only to decayed *Ruppia,* but also to a green *Chara.* The main supply was obtained from the outlet of the west arm of the lagoon, which is moderately deep with *Ruppia* growing plentifully on either bank. No specimens were observed along the west bank which receives the force of the current from the lagoon; but all along the opposite side as far as it was sheltered from the direct course of the current, the hydroid grew in profusion below the surface, attached to blackened stems of *Ruppia.* It would seem then that the hydroid from Tomahawk shuns the direct sunlight and favours a sheltered situation in slowly moving fresh or slightly brackish water.

This corresponds with the description of the localities recorded for *C. lacustris* in various parts of England,* but is, on the contrary, quite the reverse of the conditions described by Clarke (1878, p. 232) for *C. lacustris* in Curtis Creek, near Baltimore, U.S.A. In this latter case, the mouth of the creek has a narrow channel on one side

*See for example *Nature*, 1891, vol. 44: J. Bidgood, p. 106; T. Shepheard, p. 151; H. Scherren, p. 445.

flowing out into the sea, and Clarke describes the locality thus:—
"In the Channel where the sunlight is the strongest, owing to the much less abundant growth of vegetable life, where the current is most rapid and nearest to the mouth, where the changes in the

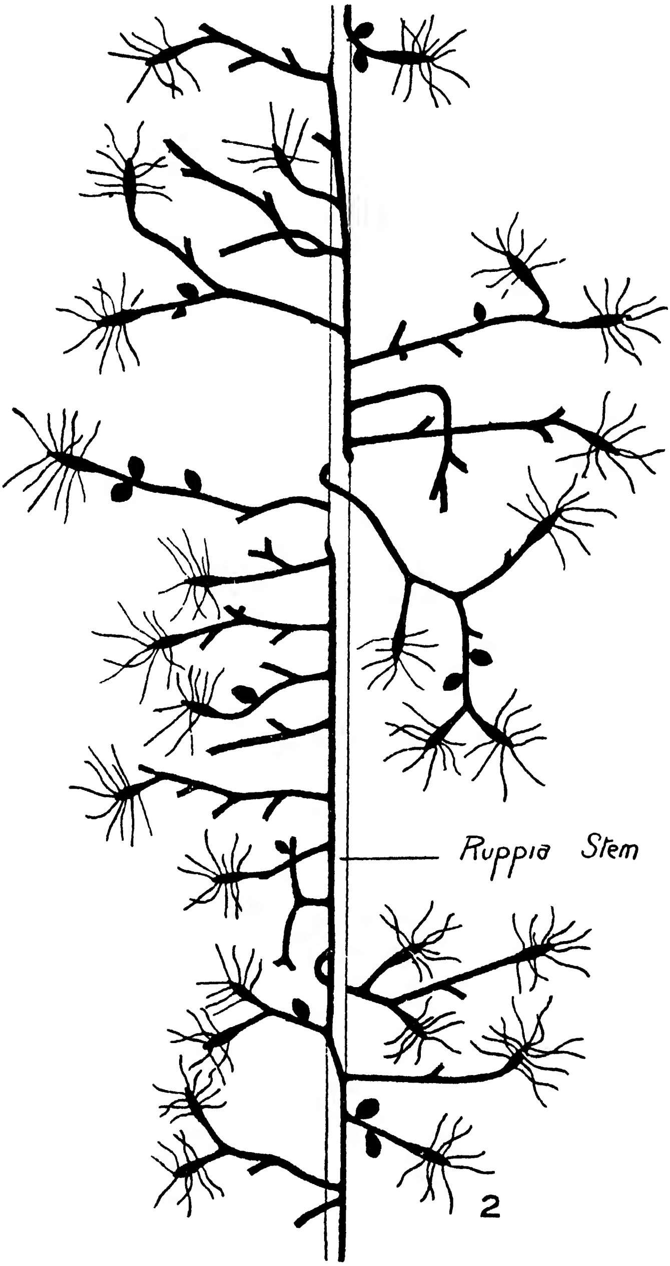


FIG. 2.—A Colony of *Cordylophora lacustris* var. otagoensis attached to the Stem of *Ruppia maritima*.

surrounding conditions must be greatest, there we found the colonies in their greatest luxuriance." *C. lacustris* must, then, be capable of adapting itself to a complete change of habit, and it follows that the new variety here described also may later be found to flourish under conditions somewhat dissimilar to those described in this paper.

Specimens from the outlet were collected at various times throughout the year from March to September. The colonies were largest and most abundant during March and April. Those collected at the end of March had female gonosomes only, but in the middle of April the colonies were found to be nearly all males with occasional females. At the beginning of June the older colonies were not so flourishing and carried only occasional female gonosomes, while a fortnight later these had all disappeared and the majority of specimens collected were young growing colonies. Unfortunately, during the period of wet weather which then intervened, the lagoon rose rapidly, making it impossible to collect from the outlet. In September, when the waters had regained their normal level, it was found that the outflowing current had carried away all the *Ruppia* from the banks of the outlet, and with it the hydroid. The only specimens that could then be found were those from under the culvert at the junction of the two arms, and these bore no gonosomes.

DETAILED DESCRIPTION.

The Trophosome: The hydrophyton consists of a moderately branched hydrocaulus springing from a long, straight (or slightly turning), unbranched hydrorhiza (see Fig. 2), occasionally observed dividing into 2 branches, each twining along a stalk.

The stems from which the hydranths spring do not differ in any way—colour, thickness, texture, general appearance, etc.—from the main stalk which attaches itself to the *Ruppia*-stems. This main stalk seems to be the hydrorhiza and is quite different from that of the typical *C. lacustris*, which is much branched. In most cases the hydrocaulus is relatively small—under 2 cm.— and little ramified; but in some specimens from deeper water, what seems to be the hydrocaulus is much longer—up to 4 cm.—and more branched. As fragments of weed are occasionally found attached to this, and as the weed easily rots away, it is uncertain whether this is a well-branched hydrorhiza or whether the hydrocaulus is capable of attaching itself to the weed.

The hydrocaulus in the smaller and younger colonies is usually unbranched. In the fully developed colonies it is irregularly branched, the average number of hydranth-bearing branches (exclusive of the terminal hydranth) being three, though the maximum number observed was five. The average height in the large colonies is about 10 mm. to 18 mm., while the largest hydrocauli in the smaller colonies do not usually exceed 7 mm. to 9 mm.

The perisarc is transparent, with about ten close annulations at the origin of each branch, and gradually loses itself on the neck of the hydranths.

The hydranth (see Fig. 3 B) possesses the same general shape as in *C. lacustris,* i.e., the proximal half is cylindrical, very slowly

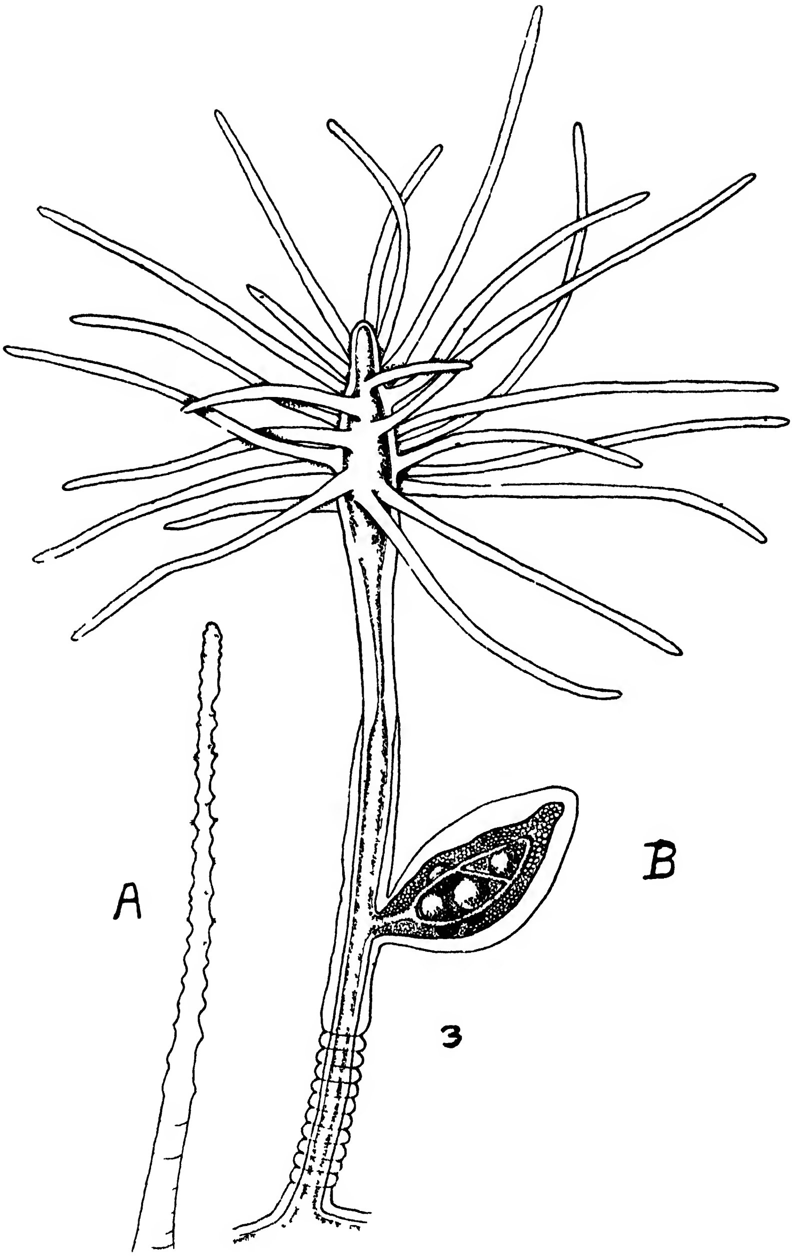


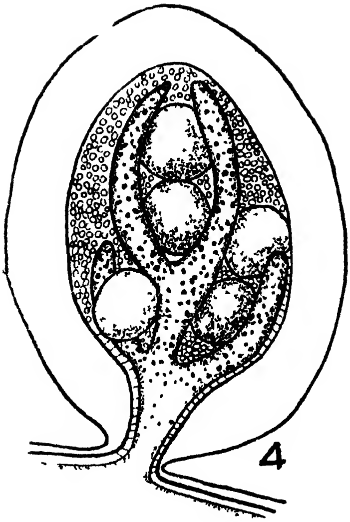
FIG 3A.—A Tentacle enlarged to show the nematocysts.
FIG. 3B—Hydranth with young female gonosome.

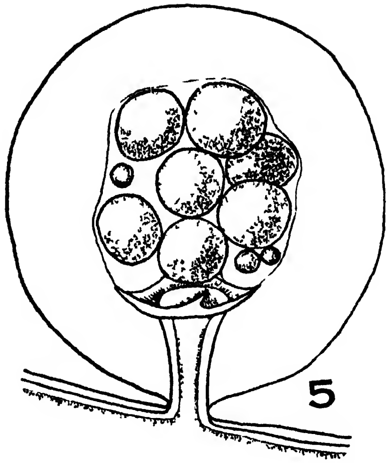
swelling to a point below where the tentacles commence, and thence swelling rather more rapidly to a point where there is a contraction and prolongation into a distinct snout—like hypostome. The colour is milky white and translucent, deepening to pale buff towards the base of the hypostome. The tentacles vary in number from about thirteen on young hydranths to an observed maximum of thirty on a large polyp (average about twenty-three). They are simple, filiform and very slender, being about one-sixth the width of the lower part of the hydranth; minute nematocysts are scattered over the whole surface as in the typical *C. lacustris*, and the extremities are very slightly thickened (see Fig. 3 A). The tentacles are twice as long as the gastrovascular cavity, and are characteristically disposed as follows: none project forward in line with the hydranth; those that grow on the distal quarter of the hydranth (about two-thirds of the total number) spread out in angles up to 45 degrees, while the remainder project at right angles to the hydranth or even bend backwards a little The tentacles, even when fully retracted, do not all point forward as in Allman's figure of *C. lacustris* (Allman, *loc. cit.*, pl. 3, Fig. 1) but at least one-third of them still point horizontally or backwards.

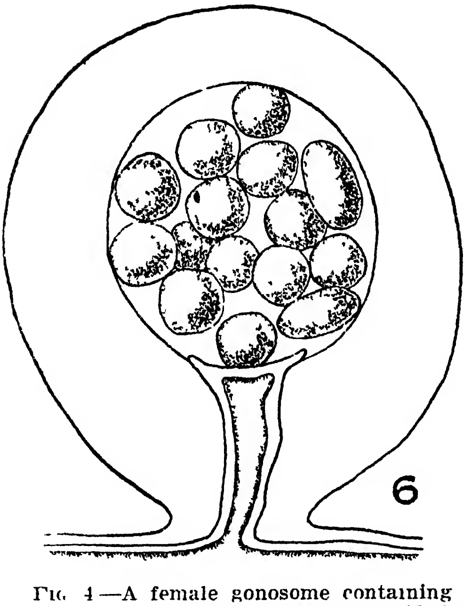
The Gonosome (see Fig. 3 B) is adelocodonic, ovoid in shape, with the proximal portion broadened. The gonotheca is almost filmy in thickness, in contrast with the several layers shown in Allman's figure of *C. lacustris* (Allman *loc. cit.*, pl. 3, Figs. 1, 3), and is separated by a wide space from the perigonium which is also a thin film of the same general outline as the gonotheca.

(a) *The Female*: The gonosome is at first moderately elongate and bluntly pointed. (See Fig 4.) Inside the perigonium can be seen several arms of the spadix enclosing obscurely outlined eggs. These arms are continuous with the coenosarc and are marked by larger and darker dots. In the early stages they are short and only slightly branched, but later become more branched and extend to the distal end of the gonosome. As development proceeds, the gonosome becomes more spherical. the arms of the spadix gradually disappear, and the whole space enclosed by the perigonium is completely filled by about 10 to 15 large, globular eggs. The ripe gonosome is larger than a fully contracted hydranth, and is about half as long as an expanded one. The spadix also is much reduced, there being no trace of the long, hollow, club-like process seen in the typical *C. lacustris* of Europe, but what remains is only a short stalk terminating in a cup-shaped body a little broader than an egg (see Fig. 5). In some specimens, four equidistant pointed projections were distinctly visible at about right angles to the axis of the stalk, and it may be that these projections represent the extremely reduced remnants of the radical gastrovascular canals. (See Figs. 5, 6.)

During development the eggs increase in size and often become fewer in number. This is perhaps due to the fact that the perigonium encloses both egg-cells and nutritive cells, the former of which grow at the expense of the latter. Moreover, in a few specimens of well-developed gonosomes, very small cells were observed among the larger ones (see Fig. 5)—in one case five of each kind—which would suggest that the small cells are reduced nutritive cells. One or two







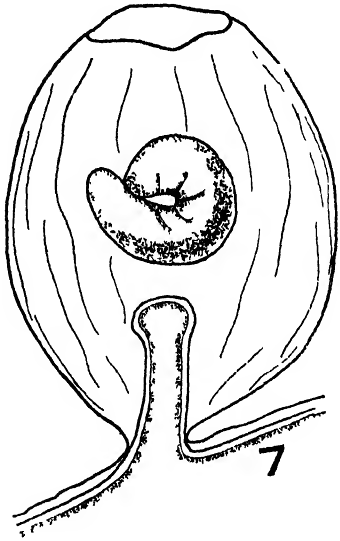


Fig. 4.—A female gonosome containing ova which are enclosed in the branches of the ramified spadix.

Fig. 5.—A female gonosome more advanced than Fig. 4; the ramified spadix has disappeared.

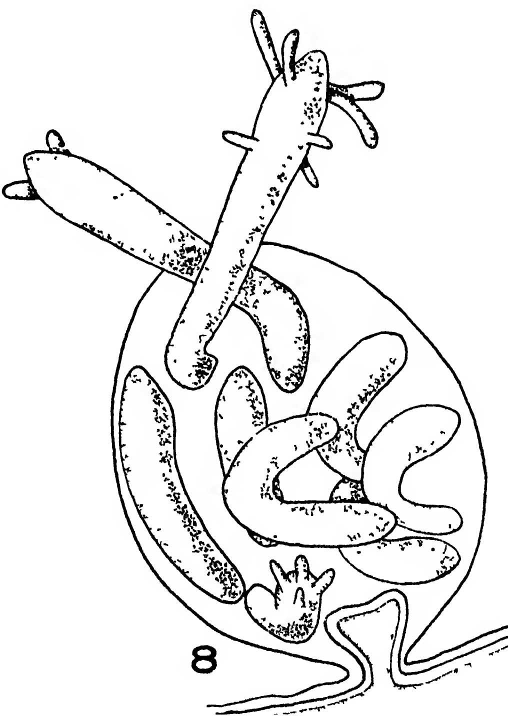
Fig. 6.—A further stage in the development of the female gonosome in which two of the ova have become planulae moving about inside the perigonium.

Fig. 7.—A ruptured female gonosome from which all the planulae have escaped except one.

such cells are often found inside the gonosome after the escape of the planulae.

Although fertilization and development of the ova take place inside the gonosome, it was not discovered how the spermatozoa reach the ova inside the gonotheca and perigonium. Careful examination of both membranes showed no aperture through which the spermatozoa might enter, and it was only later that the planulae in escaping ruptured the wall of the gonotheca. The fertilized egg-cells become slightly oval and gradually develop into elongated ciliated planulae which may be seen inside the gonosome moving sluggishly over the eggs which have not yet completed their development (see Fig. 6). There are usually about seven fully developed planulae in one gonosome, and these do not escape immediately but move round inside for several days. In one gonosome the planulae were observed moving for six days before the first one escaped. After the escape of the planulae, the spadix rapidly atrophies and disappears, and the gonotheca breaks off and floats away.

(b) *The planula* (see Figs. 7, 8): The planula escapes almost imperceptibly from the gonosome, moving slowly from side to side through the orifice till it is quite free when it moves off much more quickly. It is much longer than that of *C. lacustris* (s. str.), being the same length as the entire gonosome. It is cylindrical and slightly tapering, and when escaping from the gonosome, it orientates itself



8

FIG. 8.—A female gonosome containing planulae, some of which have already developed tentacles.

so that the blunt end escapes first (see Fig. 8). Under high magnification, dense and extremely fine cilia are observable, longer and finer than those represented in Allman's figure of *C. lacustris* (Allman, *loc. cit.*, pl. 3, Fig. 5); they are as long as the width of the ectoderm, but move so rapidly as to be hardly discernable. Occasional planulae which had evidently been delayed in escaping were observed with well formed tentacles, while still inside the gonosome (see Fig. 8), but this does not seem to be the general rule.

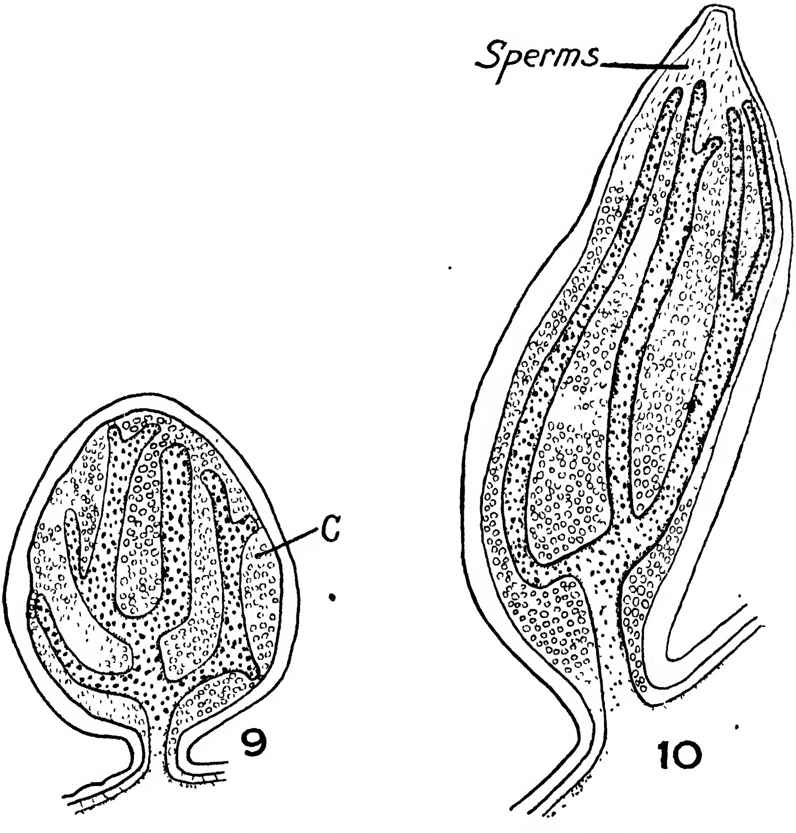


FIG. 9.—A young male gonosome with ramified spadix enclosing sperm mother cells (C).
FIG. 10.—A male gonosome more advanced, showing the fully developed spermatozoa at the distal end.

How long the planula leads a free-swimming life was not discivered, owing to the difficulty of keeping specimens alive under laboratory conditions, and although several planulae remained active for about ten days, after that period they became sluggish and gradually died.

(c) *The Male* (see Figs. 9, 10): In the early stages the male gonosome is much the same size as or slightly smaller than the female. It is subspherical, and inside it can be seen the arms of the spadix which are more branched than in the female and are similarly marked with dark dots. During development the gonosome becomes

very much longer and narrower, tapering to a point at the free end (see Fig. 10), so that the ripe elongated gonosome presents an entirely different appearance from the rounded gonosome of the female. The branched arms of the spadix remain throughout the development, and in between them can be seen under the low power of the microscope, numerous highly refringent dots which are the heads of the spermatozoa.

The escape of the spermatozoa takes place in the following manner. During the day previous to their escape the spermatozoa are seen in the clear distal end of the gonosome, moving about continuously (see Fig. 10). Just before their release there is a sudden intensity of movement which forces the end off the gonosome. The spermatozoa escape forthwith in a stream of mucilaginous material in which they remain entangled, moving hither and thither until the surrounding water slowly diffuses through it. All the spermatozoa do not escape at the same time, but the discharge takes place at intervals which may continue over a space of one or two days. A gonosome was mounted on a slide with fluid, the act of putting the cover on top being sufficient to force out the contents of the gonosome. Under high power these actively swimming spermatozoa were clearly visible and on staining with weak iodine the head and tail were definitely shown.

DISTINCTIVE CHARACTERS OF SUBSPECIES "OTAGOENSIS."

Trophosome: Hydrorhiza unbranched or only slightly ramified; hydrocaulus attaining to 4 cm.; perisarc with about 10 close annulations at origin of each branch, and gradually losing itself on neck of the hydranth; tentacles about 23 in number, twice as long as the gastrovascular cavity.

Gonosome: Gonotheca thin, transparent; spadix in ripe female very much reduced, with characteristic cup-shaped body at the distal end: development of gonosome, March to June.

Habitat: Attached to stems of *Ruppia maritima* (or less often *Chara*) in fresh or slightly brackish water, below the surface.

LIST OF REFERENCES.

ALLMAN, G. J., 1871. *A Monograph of the Gymnoblastic or Tubularian Hydroids*, Ray Society, London.

BALE, W. M., 1924. Hydroids from the New Zealand Coast, *Trans. N.Z. Inst.*, vol. 55, p. 225.

CLARKE, S. F., 1878. A New Locality for *Cordylophora, American Naturalist*, vol. 12, p. 232.

FARQUHAR, H., 1894. Descriptions of Two New Gymnoblastic Hydroids, *Trans. N.Z. Inst.*, vol. 27, p. 208.

FARQUHAR, H., 1895. List of New Zealand Hydroida, *Trans. N.Z. Inst.*, vol. 28, p. 459.

FINLAY, H. J., 1928. Notes on New Zealand and Australian Gymnoblastic Hydroids, *Australian Zoologist*, vol. 5, pt. 3, p. 257.

HAMILTON, A., 1883. A Fresh-water Hydrozoon, *N.Z. Journal of Science*, vol. 1, p. 419.

HILGENDORF, F W., 1897. On the Hydroids of the Neighbourhood of Dunedin, *Trans. N.Z. Inst.*, vol. 30, p. 200.

STECHOW, E., 1912. Hydroidien der Münchener Zoologischen Staatssammlung, *Zool. Jahrb. Jena Abt. f. Syst.*, 32, p. 333.

Chatham Islands.
The Physical Features and Structure.

By R. S. ALLAN, M.Sc., Otago University.

[*Read before Otago Institute 14th August, 1928; received by Editor 5th September, 1928; issued separately, 25th March, 1929.*]

PLATE 103.

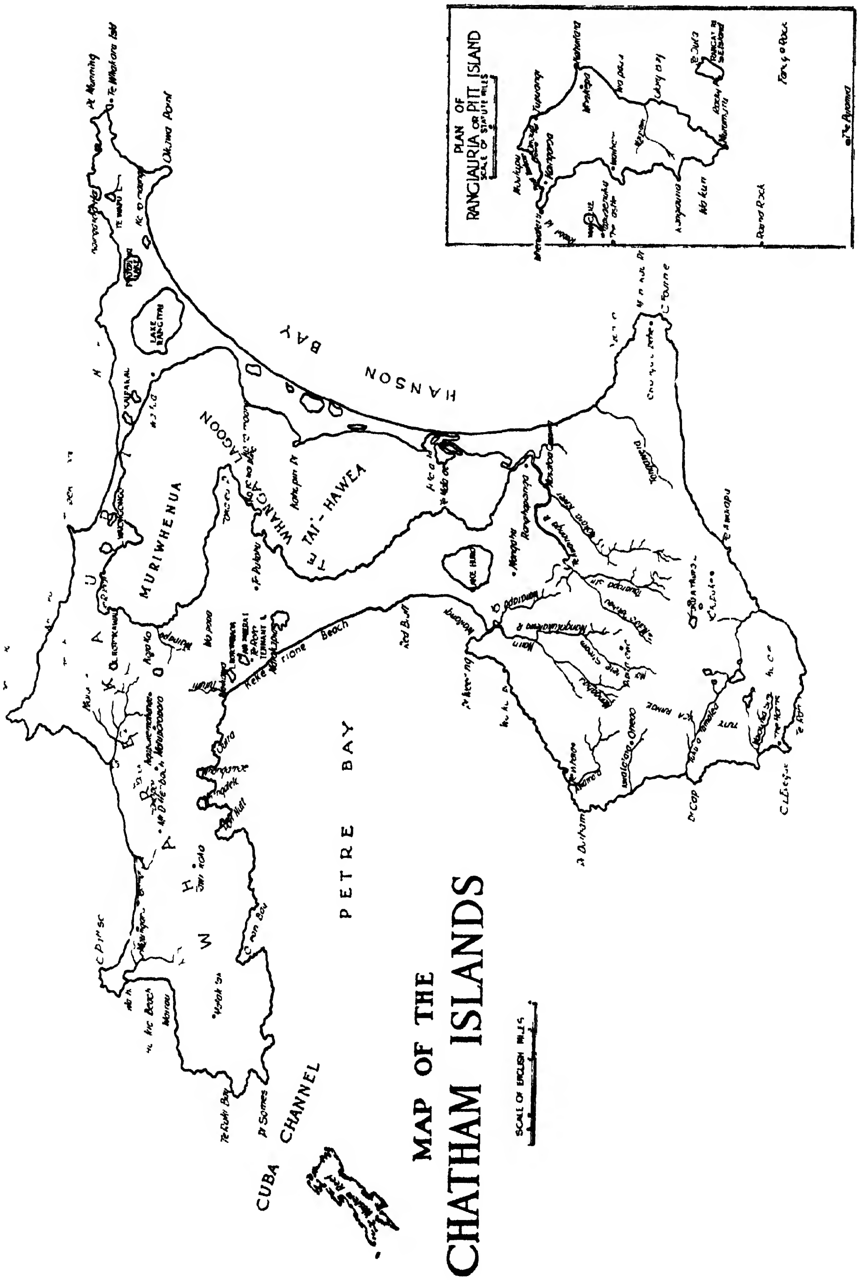
CONTENTS.

1. BRIEF HISTORICAL SUMMARY.

THE physical features of the Chatham Islands were first investigated by Dieffenbach in 1840 or thereabout, and since that date several writers have made references *inter alia* to the surface features of the group. Travers (1868) includes comment thereon, but little idea of the topography can be gathered from his remarks. Robertson (1890) and Forbes (1893) give general accounts of the Chatham Islands, in which some observations are of value. Especially valuable, however, is the very accurate topographical map prepared by John Robertson and S. Percy Smith in 1868 and 1883, which goes with the latter's report. Florence (1900), also, gives useful notes on general topography, climate, etc. Cockayne (1901) gives an excellent account of the physiography as it influences plant ecology. The most recent report on the subject is found in Skinner's memoir on the Moriori, the extinct inhabitants of the group (1923).

2. PHYSICAL FEATURES.

(a) *Size, shape, etc.*—The group of the Chatham Islands comprises the Main or Chatham Island (Rekohua) and the group of small islands lying to the south east, of which Pitt Island is the largest. The area of the Main Island is 222,490 acres, of which lagoons occupy 46,000 acres. The greatest length of the island as


MAP OF THE
CHATHAM ISLANDS
PLAN OF
RANGIAURIA OR PITT ISLAND
HANSON BAY
PETRE BAY
CUBA CHANNEL
TE WHANGA LAGOON
MURIWHENUA
TAI - HAWEA
LAKE RANGITAI
Okawa Point
Red Bluff
Kekerione Beach

a whole measured from north to south from Cape Young to Te Rahui is 30 miles and the greatest breadth across the northern portion of the island from Te Whakaru Island to Te Raki is 35 miles. For convenience in description, Chatham Island may be divided into three portions—a northern, a central, and a southern. The northern portion consists of two peninsulas, lying on either side of the northern and widest portion of Te Whanga Lagoon, and connected only by the very narrow strip of land which in the north separates the lagoon from the ocean.

The western peninsula, Whareka, is about 16 miles in length from Point Somes to Waipapa on Te Whanga Lagoon: and 7 miles at its widest base from the north of Waitangi Beach to the shore near Wharekauri. The average width in the north-south direction is about 4 miles. On the north coast two prominent peninsulas terminate in Cape Pattison and Cape Young respectively. On the south coast and to the west lies Ocean Bay, and further to the east the three smaller indentations Port Hutt or Whangaroa (the only safe harbour of the group), Whangamoe, and Whangatete. Off Point Somes, and separated from it by Cuba Channel, lies the Western Reef or Rangihokopoi which, awash at low water, is a constant menace to shipping.

The eastern peninsula is relatively small, being of narrow triangular shape 9½ miles in length and 5 miles wide at its base. The apex of the triangle is a rocky schist-formed cape called Point Munning, while three miles south Okawa Point forms the north boundary of Hanson Bay. Facing north, thus sheltered from the southerly and south-westerly gales, is Kaingaroa Harbour, where a refrigerating plant is established.

Most of the central portion of the island is occupied by the southern part of Te Whanga Lagoon. On the east this is separated from Hanson Bay by a narrow strip of low swamp and sand-dune, stretching 27 miles from Okawa to Owenga. On the west the land bounded by Petre Bay is of greater extent and of greater elevation, having a width in the south of 2½ to 3 miles and in the centre 1½ miles, while in the north a broad triangular area stretches into the lagoon.

The southern part of the island is a compact 4-sided block with maximum length of 9½ miles from Petre Bay to Pitt Strait, its southern boundary, and a breadth of 13 miles from Manakau to the Horns.

(b) *Topography of Southern Plateau.*—This block is roughly rectangular in outline, with a prominent peninsula forming the south-east corner and terminating at Manakau and Cape Fournier. It is best described as the much-dissected remnant of a plateau-area which is nearly at sea-level along the south end of Te Whanga Lagoon, but reaches a height of nearly 1,000 feet along the south coast. The highest peaks, which form the divide between the northward and southward flowing streams, lie along and very close to the south coast. The latter is a fault-coast consisting of a series of bold cliffs ranging in height from 600-700 feet. The most prominent peaks in this divide from west to east are Te Whakahewa (the Horns) (865 ft.), Karori, an unnamed peak near the south of Te

Awatapu (938 ft.), two unnamed peaks further east, respectively 865 ft. and 733 ft. and finally Te Ranga (331 ft.) forming the eastern peninsula.

From the Horns, high broken country extends in a northerly direction to Pipitarawai (931 ft.) a peak heavily wooded and difficult of access. This range from the Horns to Pipitarawai forms the main divide separating the northward flowing streams in the east from those which flow to the west.

Nearer the west coast is another stretch of high country, the Tutenga Range, which forms the north-west slopes of the block, the highest points being Whangamarine (771 ft.), Oehau (640 ft.), and Te Whata (441 ft.). An extension of this range runs north with decreasing height almost to Waitangi.

In the interior a smaller ridge diverges from Pipitarawai, and running north-east divides the Tauaropa Stream, a tributary of Te Awainga River, from the Mangatukawera and the Mangahau, which unite to form the Nairn.

In the north of the block, Mangahau (356 ft.) is a more or less isolated peak.

(c) *Topography of Central and Northern Areas.*—In strong contrast to the southern area, the northern is lowlying, while mature slopes are the rule.

As a whole this area is roughly T-shaped. On the west side is the large indentation, Petre Bay, which is roughly square in outline, which suggests that it owes its origin to subsidence of a large block formerly bounded in the south by the coast from Waitangi to Point Durham, and on the north by the coast from Waikawa to Point Somes. Apart from their straightness, both these shore-lines give evidence that they may be classed as fault-coasts.

On the east side is Hanson Bay, which stretches from Owenga in the south to Okawa in the north, and is separated from Te Whanga Lagoon, which occupies most of the stem of the T, by a very large lowlying sandspit.

The central area extending from Waitangi to Te Roto and Waipapa, is highest at Red Bluff (244 ft.), and at Te Pukahu (210 ft.), but is generally much lower. In the main it is limestone country, and everywhere has been eroded into mature rounded slopes of monotonous regularity. Except along the west shore of Te Whanga and at Red Bluff, outcrops are rare. Most of the area is covered with fern or scrub.

The small north-east peninsula is featureless swamp-covered country with outcrops restricted to the coasts. The highest points are Waitua (90 ft.), Matarakau (126 ft.), Kaingaroa Hill (193 ft.), and Koromaunga Hill near Okawa Point.

The north-west peninsula is of greater interest. The north central area surrounding Wharekauri was a region of volcanic activity and shows volcanic piles in various stages of erosion, depending largely on whether the hills in question are composed of solid lavas or relatively soft tuffs and breccias. Rangitihi (627 ft.) is a rounded bush-covered peak, while other peaks are Puhina (327 ft.), and Motuariki.

The remainder of the peninsula is a remarkable uniform peneplain cut in the old schist undermass. The peneplain is slightly tilted, being near sea-level along the north coast, but considerably higher, in one place as much as 230 ft., along the south coast. The uniformity of the surface is broken by several volcanic residuals which have frequently been eroded into almost perfect cones. In all cases, however, the peaks represent, not craters, but blocks of the covering sheet of Tertiary rocks which have escaped complete erosion. Hence the peneplain is a "fossil plain." The main peaks of the area are Korako (588 ft.), Ngapukemahanga, Motuporoporo, Hokopoi, Dieffenbach, and Maunganui (587 ft.). Since these are in practical alignment in an east and west direction, and since the strike of the underlying schist is east and west, it seems probable that these represent a line of structural weakness. Two further peaks off this line are Tawhirikoko, and Matatakitaki (518 ft.).

Maunganui is a picturesque rugged pile composed of some 500 ft. of tuffs overlying a flow of monchiquite and a limestone. The northern side represents an old cliff-face and gives evidence of minor fluctuations of level discussed below.

(d) *Lakes and Lagoons.*—A large area of this island-group is covered by lakes and lagoons. Of these the most noteworthy is Te Whanga Lagoon, which occupies about one-fifth of the total area of the island.

It is roughly shaped like an inverted L. The southern arm is called Tai-Hawea, while the northern east-west wing is Muriwhenua. On the north and east sides the lagoon is bounded by long low-lying sand-bars. The northern bar is the older, and is covered for the most part with peat swamp. The eastern spit stretches from Okawa Point almost to Owenga—a distance of 27 miles.

The length of the lagoon, north and south, is 15 miles; while the length of the north arm is 9 miles. The widest part of the southern stretch is 5 miles across.

The west side from Tokatea Point to Te Matarae is bounded by low limestone cliffs. From the former point west and north to Te Rahui the cliffs are still lower and consist of limestone, schist, and basalt.

Little is known as to the depth of the lagoon, but it seems that it is generally shallow. After prolonged south-west gales the waters are banked up, exposing large tracts of weed-covered bottom.

Cockayne notes that "the floor of the lake consists of sand or of sandy, peaty mud, formed from the decay of many generations of plants." (1901, p. 272.)

The lagoon can be crossed by two main fords. One from Korowaipuna to Kahupiri Pt.—a distance of 4 miles—lies for part of the way on a submerged shelf of hard limestone. This is the main thoroughfare from Waitangi to Kaingaroa. The second ford crosses the narrow southern area from Te Matarae to Hitara Island.

The eastern side of the lagoon is bounded by an extensive line of moderately-recent sand-dunes, through which the lagoon periodically breaks a passage out to sea. No evidence was obtained as to how often this overflow occurred, but it may be noted that it was running freely at the time of our visit.

This large lagoon is almost certainly a cut-off arm of the sea, the inner coast being clearly an old sea-cliff. This old shore-line probably commenced in the north near Taupeka Point, followed the present western margin of the lagoon to Te Matarae and thence by way of Lake Huro to Petre Bay.

Lake Huro, which lies between the southern end of Te Whanga and Waitangi, was formerly part of Te Whanga. It is separated from Petre Bay on the west and from Te Whanga on the east by low sand-hills or swampy ground.

Lakes Rangitai and Pateriki in the north-east peninsula are probably of like origin. They are both surrounded by low-lying peat swamp and have been separated from Te Whanga by the formation of sandspits. Pateriki is separated from the sea on the north only by a small line of very recent dunes.

Several other lakes, e.g., Wharo, Waiongongo, Kaipakau, and Te Wapu, owe their form and position to similar circumstances.

Another type of lake is represented by Rotokawau, and some others unnamed lying on the flat peneplain in the north-west peninsula of the island. These lakes are small and shallow, and occupy depression in peat land. They probably fill areas which have been burnt out of the peat by ancient fires. There is usually no drainage into them—at least by way of streams.

A third type of lake is found near Te Roto. Here is a series of fairly large lakes of beautiful, clear fresh water. These are, from north to south, Rotoparaoa, Ahi-Parera, Te Roto, Tennant Lake, and Marakapia. These lakes are picturesquely situated in a series of bush-surrounded depressions, Tennant Lake and Marakapia being of considerable size. Their origin is not clear, but their presence is probably due to a combination of two factors—the formation of old and recent sand-dunes on their seaward side and solution of the underlying limestone. No data as to depth are available.

(e) *Streams.*—The two largest streams are the Nairn and Te Awainanga. The Nairn rises from the great peat swamp area on the north side of the Tutenga Range. Its two main tributaries, the Mangahau and the Mautere, flow in a north-east direction, and drain a large area. The main part of the Nairn flows north to enter the sea at Waitangi—the chief township. In early whaling days the mouth of the Nairn gave a safe anchorage and a constant supply of fresh water.

Te Awainanga, the largest stream in the group, which has its source in the high swampy country round Lake Tuku-a-Taupo, drains nearly one-third of the southern plateau region. The main tributaries are the Makara, Tauaropa, and Te Mata-o-pakihau. At Moeatoa Ford, Te Awainanga passes over a basalt flow as a picturesque waterfall. The stream here has considerable volume, and the fall is a potential source of electrical power. Below this, Te Awainanga flows through low swampy flats into the south end of Te Whanga.

Both these streams, in fact most of the streams of the island, are very sluggish; their water is a dark-brown colour, and where their bed is not on basalt, it is usually covered by a layer of peaty mud. The streams which drain the south-west corner of the island

are very different. The Awatotara, the Tuku-a-Tamatea, and the Waipurua are all vigorous streams of fresh pure water. They are older than the uplift which gave rise to the plateau, and hence have cut out deep narrow gorges. The Waipurua stream enters the sea over a ledge of columnar basalt, falling about 40 ft., and forming a magnificent spectacle when the creek holds any volume of water.

Few creeks enter the sea on the southern coast—the divide between the north-flowing and south-flowing drainage systems being very close to the sea cliffs; in fact one can stand about 50 yards from the cliff-face and look northward right down the valley of the Tongarewa Creek to its mouth near Owenga.

In the northern half of the island the drainage-system calls for little description. The Waihi in the west, the Tutuiri near Tioriori, and the Waipapa running into Te Whanga, are all of fair size and drain large areas of swamp land. Of these three the Tutuiri has the largest watershed. The water is always tea-coloured and slightly acid.

The relation between drainage lines and geological structure will be discussed later.

(f) *Swamps.*—There is little of the surface of the island that has not at least a superficial covering of peat. The climate seems to be peculiarly suitable for the luxuriant growth of peat-producing plants. Accumulation of peat is as a rule most extensive in cool, damp climates such as that of Ireland, and the Chatham Island deposits seem therefore to be formed under normal conditions.

Almost the whole of the north-west peninsula, which is in the main a slightly-tilted peneplain, is peat-covered. The swamp-area extends from the foot of Korako and passes west to the end of the peninsula. From Tawirikoko to the west coast the swamps are very extensive, and contain a large volume of water. Another extensive area is found between Motuariki and Cape Young. The watersheds of the Waipapa and the Tutuiri drain yet another peat-covered region. The north-east peninsula from Taupeka Point eastwards is likewise monotonously low-lying and swampy. Smaller swamps are found near Lake Marakapia and again in great extent round about Lake Huro. The Nairn and Te Awainanga streams drain many square miles of swamp covering the southern plateau.

Peat swamps are in fact so general that they are a hindrance to geological investigation. The main outcrops of rocks are to be found along the shore-lines. In winter the swamp areas are impassable, and even in such a favourable season as our expedition experienced, many of the bogs and sphagnum depressions were so wet as to make dangerous any attempt at walking across them. Peat must have been forming for a considerable period. At Whangatete Bay there are cliffs of peat nearly 40 ft. in height—these cliffs contain at least three buried forests. It is of interest to note that in the present swamps are numbers of large totara (*Podocarpus totara*) logs. The totara is not now found growing anywhere in the Chathams.

(g) *Coast-lines.*—For its size the Chatham Island group has a great linear extent of coast-line: and, since the rocks of the group

FIG 1—Schist coast, Waikawa, looking west along the strike
(*Photo by Wm Martin*)

FIG. 2.—Uplifted platform, Mopihanga Creek, Ouira Bay.
(*Photo by Wm Martin*)

are extremely diverse—metamorphic, sedimentary and volcanic rocks being represented—the variety of coastal profile is considerable.

(1) Coasts cut into quartz-mica-schists. This type of coast is beautifully illustrated along the south shore of the north-west peninsula from Waikawa to Point Somes. (See Fig. 1.) The shore is approximately parallel to the east and west strike of the schist, while there is an average uniform seaward dip of 30° S. As a rule the shore-zone is wide and the profile regular and of slope less than the angle of the dip. Weathering seems to occur most readily in the direction of the strike, hence fissures running in this direction are the rule.

This shore appears to have been due initially to faulting, but has since been depressed and is now aproaching a mature stage. The tributaries of the streams that enter the indentations on this shore (Ocean Bay, Whangaroa, etc.) have been converted into independent streams. In other words, the bays are small drowned valleys, the creeks are betrunked, and the small river-systems are dismembered. More recently a slight uplift occurred and there is a wave-cut platform, now 10-15 ft. above high-water. This is clearly seen on the basaltic columns which are intrusive into the schists at Ouira Bay. Fig. 2.

A rather different coast-type is found in the schist area from Kaingaroa to Point Munning. Again the strike is parallel to the coast but the dip is very steep—from 65° to 80° N. The coast is therefore very rugged and broken, consisting of a series of razor-back ridges running east and west. Stacks are of frequent occurrences.

(2) Coasts cut into sedimentary and tuffaceous rocks. Such coasts are well developed in the Wharekauri-Cape Young-Tioriori section in the north of the island. The rocks differ considerably in hardness and stratification; tuffs, massive or well bedded, soft greensands, and occasionally lava-flows and dykes go to make a most irregular coast. Generally the cliffs are abrupt and youthful, talus-slopes are not greatly in evidence, but well-defined wave-cut platforms are a feature.

At Red Bluff cliffs cut in hard limestone and tuff rise sheer from the sea. South of Waitangi fine cliffs are cut into tuffs and tufaceous limestones. Wide, flat, and remarkably regular wave-cut platforms are here beautifully developed. The shelf is often more than 20 yards wide and is covered at high-water. In places it is littered with large fallen blocks of tuff. It stops suddenly, and there is a vertical drop into deeper water (about 6 fathoms at Waitangi cattle-yard).

Similar platforms are cut into well-bedded tuff at Owenga, at various places on Pitt Island, viz., Onoua, Moutapu, Kahuitara, on the north and east coasts of South-east Island, and elsewhere.

(3) Dune-coasts. Sand-dunes, some of Pleistocene age and others formed within the history of man, form large stretches of the coast-line. The most notable rise from a huge spit running from Okawa to Owenga, 27 miles, which cuts off an extensive arm of the sea to form the large lagoon, Te Whanga. The dunes here reach a height of 60 ft., but the average is much less. On the inner side

of this spit are great stretches of fine sediment covered with salt-marsh vegetation. This area seems to be gradually encroaching on the lagoon region. (For a description of the salt-marsh areas see Cockayne, 1901.)

A coastal strip of high dunes runs from Matarakau to Wharekauri, and another from Waikawa to Waitangi. Much of this dune-formation is of recent origin, and this is accounted for by the introduction of stock, which tramped down or ate out the succulent plants formerly acting as binding agents fixing the dunes. Immediately north of the mouth of the Nairn, fifty years ago low swamp extended almost to high-water mark, but there is now on the seaward side of the swamp which extends inland to Lake Huro an extensive zone of dunes a quarter of a mile wide and 50 to 60 ft. high. These dunes and others elsewhere have been planted in coarse grass, which helps considerably to check further advance. These facts, given by Messrs. Seymour and McClurg, receive support from the occurrence of seams of peat, containing large logs, which outcrop on the Waitangi Beach.

At the north end of Kekerione Beach from Waikawa to Te Roto, and again further north between Taupeka and Matarakau, advancing dunes are burying former extensive forests of karaka (Moriori *kopi*, *Corynocarpus laevigata*).

Although the introduced stock may upset the equilibrium between vegetation-control and dune-formation, this factor cannot be the only one at work. An area covering several square miles of more ancient dune (in the formation of which stock played no part) is found on the shores of Te Whanga between Waipapa and Titirangi.

In several localities the existence of more than one cycle of dune-formation is shown, and different phases of the present cycle may be noted. Thus at Te Roto, dunes are forming at an alarming rate, i.e., progradation is occurring; while at Maunganui and elsewhere on the north coast the first cycle dunes are suffering degradation by the continued action of the sea-waves.

(4) Coasts cut in volcanic rocks. At Maunganui the coast shows several interesting features. Maunganui itself stands guard as a bold, rugged rampart over the western end of the north-west peninsula. On the seaward side it rises almost perpendicularly from sea-level to a height of nearly 600 ft. Its lower portions are protected by huge talus slopes covered with native bush. The cliff is of a composite nature being cut into limestone, overlain by limburgite and followed by a huge accumulation of coarse volcanic tuff. It gives evidence of relative uplift in recent times. The seaward slopes of the peak are obviously wave-cut. At the present time they are distant 150 yds. from high-water mark. Since uplift, progradation has occurred—a line of high sandhills of some antiquity lies between the cliffs and the sea. These were much more extensive 50 years ago (*vide* C. Seymour) and were covered by *akeake* (*Olearia Traversii*) and *karaka* forests half a mile in width.

Thus we have the following sequence of events:—

(1) Cutting back of the cliffs.
(2) Uplift and formation of talus slopes.
(3) Progradation.
and (4) Cutting back of the first cycle dunes.

Further evidence of this uplift is found in the same area. A pronounced terrace runs from Maunganui towards Wairau separating the higher peat-plateau from a lower swamp-area nearly at sea-level. The latter is of the nature of reclaimed ground and is still accumulating. It is separated from the sea by a wide fringe of high sand-hills running the length of Hurikia Beach. The schist-reef forming Cape Pattison may have allowed sand-bars to accumulate inland, and these have been slightly uplifted. The height of the terrace is approximately 50 ft. above sea-level. The uplift seems to have been relatively old, since the terrace is in places almost obliterated.

A similar terrace fronted by flat swamp is found round the mouth of the Taoroa Creek, east of Maunganui. It also shows mature features.

Turning now to examine the volcanic coasts of the southern half of the main island, one sees that the west coast from Waikaripi to Durham Point and thence to Gap Point is low-lying with a gradual slope from the coast to inland ridges. The beach is composed of rounded boulders, the monotony being occasionally broken by the presence of large trachytic dykes.

The change in topography at Waikaripi is very marked. From Waitangi south to Waikaripi the sea-front is formed of tuff and then horizontally-bedded limestone cliffs 200-300 ft. high. These cliffs terminate abruptly at Waikaripi where the volcanic series commences. The presence here of a strong fault seems the obvious inference.

On the opposite side of the island from Tongarewa past Owenga to Manukau Point the same type of boulder-coast is found.

From Gap Point to the Horns (Cape L'Eveque) and thence along the whole of the southern coast of the island to Cape Fournier and Manukau Point there is a series of perpendicular cliffs ranging from 400 to 800 ft. in height. The coast-line is not straight, but must clearly be ascribed to faulting. It is now somewhat broken, and cut in places by deep gorges. In most cases the small streams draining the swampy plateau discharge into the sea by high falls. The divide between these and the northward-flowing drainage-systems is close to and approximately parallel to the line of cliffs. It seems probable that before the submergence of the Pitt Strait block, the highest point of the Greater Chatham Plateau was close to the present line of cliffs. Although this coast was observed at the Horns and at the Manukau end, it is perhaps most accesible at a central spot, Te Awatapu.

At this locality a block of some 300 acres has slipped half way to the sea. The height of the upper cliff is about 750 ft., while the top of the slipped block is about half that. Up till quite recently this area has been inaccessible from land, but a track has now been cut down the cliff-face and the former covering of primeval bush

has been felled. The slipping movement is probably still in progress; within the last two years a huge block has dropped two feet. Great landslips from the upper cliffs occur periodically, and thus immense accumulations of talus have collected and are still forming. Elsewhere along this part of the coast talus slopes at sea-level are unusual. Wave-cut platforms have been noticed in many places.

The average height of the seaward cliffs in other portions of the southern plateau is approximately 200 ft. The surface is most irregular, and probably cracked considerably during dislocation. It has subsequently been greatly modified by the deposition of detrital matter. Small lakes or centres of inland depression are common. Talus slopes are finely developed and of great size.

The cliffs along the whole of this coast are being reduced by a succession of rock-falls and land-slides. Bands of relatively soft ash between successive lava-flows become excavated, thus hastening the destruction.

(h) Pitt Island and smaller island groups. The group of islands known collectively as Rangiauria or Pitt Island consists of three main land-masses of which Pitt Island proper is by far the largest and most important. Mangere, lying off the north-west coast, and Rangatira or South-east Island are also utilised for pastoral purposes. Smaller rocky islets are numerous, the most important being Rabbit Island (Wharekaikite Motu) off Whenuataru, Little Mangere (Tapuaenuku) and the Castle (Rangiwheao) south-west of Mangere, and the Star Keys some twelve miles east of Kahuitara (North Head). Still smaller islands are numerous, especially off the southern Murumuru coast; of these Round Rock (Rangituke), Fancy Rock, and The Pyramid (Te Rekokoe) are most noteworthy; several dangerous reefs are known. The group as a whole is urgently in need of a thorough marine survey, the danger of neglect being shown by the great number of wrecks here during the last century.

Pitt Island is roughly triangular in outline, the apex being directed to the south (Murumuru Peninsula). The base of the triangle from Whenuataru to Kahuitara is six miles wide. The length of the island from Moutapu to Murumuru is 9 miles. The width from Waihere to Kahuitara is 6 miles, while from Rangiauria to Glory Bay it is 4 miles. The area of the main island is 15,630 acres, or approximately 24½ square miles.

The north-west coast from Whenuatara to Moutapu is cliff-bound but contains two small harbours, Flowerpot Harbour or Onoua, the chief port of the island, and Parimatu(?) or Boat Harbour, a small cove a mile further to the west. The latter is used as a shelter during the somewhat prevalent south-east storms. Flowerpot Harbour may be used in certain winds only and under suitable conditions, loading or unloading being by means of surf-boats. From Moutapu a stretch of sandy beach runs south-east four miles to North Head or Kahuitara, a rugged peninsula of volcanic rocks. South of North Head the coast is rocky or sandy by turn, and the coast-line swings, first into Waipaua Bay, and second, into Glory Bay which gives a good anchorage in most winds. From Glory Bay to Murumuru the coast is irregular and rugged in the extreme. On the north of the west coast Waihere Bay forms a large indentation 3 miles across.

Most of the coast is bounded by high, precipitous cliffs, but Waihere beach composed of sand lying at the foot of slipped cliffs and fallen detrital blocks, is nearly one mile in length. The south arm of Waihere Bay terminates in Waihere Bluff with vertical cliffs rising 700 to 800 ft. from the sea. Thence south to Murumuru the coast is again very irregular and rugged. Rangiauria forms a bold point with steep cliffs nearly 700 ft. in height. Murumuru rises sheer to the trigonometrical station 600 ft. from the sea.

The topography of Pitt Island is that of a plateau of a general height of 200-300 ft., much dissected by subaerial and stream erosion. On it are several high, bold ramparts of volcanic rocks, of which the most striking are Waihere (971 ft.), Whakepa (754 ft.), and Rangiauria (678 ft.). Two farther prominent heights are Whapaka (937 ft.) on Mangere, and Rocky Peak or Whakarere-oro (678 ft.) on South-east Island.

Smaller peaks of 608 and 702 ft. are found near Whakepa, of 424 ft. near Glory Bay, and of 596 ft. at Murumuru; Kaingaroa (393 ft.) is the highest point in the north of the island. The Pyramid (Te Rekokoe), a small pinnacle 6 miles south of Murumuru, reaches a height of 566 ft.

A line extending from Waihere to Whakapa divides the island into two distinct areas, so far as mere description is concerned. North of this line the land belongs to different members of the Hunt family, which has been resident on the island since about 1840. Most of this northern block, with the exception of relatively small areas near Waihere and Whakepa, has been cleared of the native bush which formerly reached sea-level all over the island, and now forms fine pastoral lands which rival the best New Zealand land in stock-carrying capacity. These favourable conditions are in a large measure due to a mild climate, and a soil derived from limestones and volcanic tuffs.

South of the Waihere-Whakepa boundary, with the exception of the "Glory Clears," the south half of the island is densely bushed, and communication can be maintained only by boat or by horse over ill-constructed and little-used bush-tracks. Outcrops of rocks are practically confined to the summits of the hills and to the often unscalable coastal cliffs.

The drainage-system of Pitt Island consists of small streams and creeks, most of which have their sources in small swamps in the uplands. The two main streams are the Tupuangi in the north and the Waipaua in the south. The Tupuangi has its headwaters on the northward-facing slopes of Waihere Hill whence it flows north for two miles in a relatively deep valley cut through tuff and marl, and enters the sea at the north end of the Onekura Beach. Near its mouth it broadens into a small lake, formed by the seaward accumulation of sand-dune. It is the only lake of any size on the island. The Waipaua is the largest stream, but the volume of water is small. It enters the sea one mile north of Glory Bay through a small gorge cut into soft tuff. It has two main branches, the south-west and larger tributary draining the high land round Rangiauria, while the north-east branch drains some of the high land between Waihere and Rangiauria.

Of the smaller creeks the Waipapaku enters the sea some two miles north of the Waipaua; another creek of note has its source at the north end of Waihere beach, flows north and enters the sea at Flowerpot Harbour, where it cuts a small gorge through the limestone down to the underlying tuff. Although the volume is small, it could probably be utilized to drive a water-wheel and so give a small local supply of electricity.

At the south end of Pitt Island, on both sides of the Murumuru peninsula, from Waikuri to Murumuru on the east, some interesting geomorphological phenomena can be observed. This peninsula is composed for the main part of horizontal or nearly horizontal volcanic tuffs which are moderately coarse-grained and as a rule imperfectly bedded. The mass is strengthened, however, as at Murumuru itself, by intrusive masses of basalts. Murumuru trigonometrical station is 596 ft. high, but the average height of the area is about 350 to 400 ft. The coast line is extremely precipitous and extensively dissected by deep ravines—where flow the master-streams. The interfluves have been reduced to steep, sharply-defined razor-backs.

On the sides of these sharply-angled ridges the process of "abstraction" is well depicted. Besides the action of the master-streams, on the seaward slopes and upper seacliff surfaces small streams, more often than not dry, finely dissect the whole surface of this area with small ravines separated by narrow, steep-sided ridges. This good example of consequent drainage and abstraction seems to be in a more advanced stage of the cycle than that figured by C. A. Cotton.*

As a result of this abstraction another process is clearly illustrated on this coast. By the formation of the ravines described many points or headlines become separated from the main block by a narrow ridge. This eventually becomes undermined by wave action and the formation of caves, or disintegrates under the continued action of the streams. Thus innumerable stacks are formed which as a rule are steep-sided and more or less conical. On the map prepared by Smith and Robertson about sixteen small islands are dotted around the Murumuru Peninsula. A few of these are, however, of volcanic origin. Many stacks are unmapped, and many more partly-formed stacks were noted.†

A short stretch of dune-coast is also present on Pitt Island extending from Tapurangi to Kahuitara; it is probable that the small Tupurangi Lake owes its formation to this cause. Advancing dunes are also gradually covering Kaingaroa Hill at a height of nearly 400 ft.

The writer was unable to visit Mangere, which lies some 3 miles off the north-west of the main island. It is roughly club-shaped, with the club-head directed to the north and the east. The north-east coast is a magnificent cliff of tuff 900 ft. high. It slopes quickly to almost sea level at the south-west end and a landing may be effected there under suitable weather conditions.

*C. A. Cotton, *Geomorphology of New Zealand*, Pt. 1, p. 68, Fig. 65b, 1922.

†For the formation of stacks, see Cotton *loc. cit.*, p. 406, Fig. 395.

The rectangular South-east Island, or Rangatira, is lowest in the north, but rises rapidly to 678 ft. in Rocky Peak in the south. The coasts, except the northern, are rugged, bold cliffs. A good landing can be made at Te Outa in the north under favourable circumstances. This island lies 2 miles south-east of Glory Bay. It is 1½ miles long in a north and south direction and 1 mile wide.

3. GEOLOGICAL STRUCTURE.

The structural features of the Chatham Island group may best be considered if the main island is divided into three large areas. The largest of these is the Southern Plateau of volcanic rocks; this area includes all the land south of an east-west line from Waitangi to the east coast a mile or so north of Owenga.

The second region lies to the north of this line and south of an indefinite line drawn from Te Roto to the north-west corner of Te Whanga Lagoon. This is the district in which limestone is the main rock.

Finally, the third structural unit consists of the schist areas found in the northern parts of the island. This last region may be further subdivided into (a) an eastern schist area, including the Waipapa Creek, Taupeka Point, and the North-east Peninsula; (b) a western schist area running from Waikawa to Cape Pattison; and (c) a north central division of volcanics and sedimentaries stretching from Tioriori in the west to Wharekauri in the east.

(a) *The Southern Plateau Area.*—Almost the whole of this block is made up of a succession of horizontal lavas and tuffs. The structure is fairly clear and simple.

The shape of the area is determined by a series of three or more parallel fault-fractures. The main line of faulting trends in a north-east direction. The southern coast which consists of perpendicular cliffs ranging from 600 to 700 ft. in height is clearly along this trend line. A strong fault runs from the Horns (Cape L'Eveque) to Cape Fournier. The northern shore of Pitt Island represents the southern side of the block which has been relatively depressed to form Pitt Strait.

The coast on the north-west side of the block, from Point Durham to Point Weeding, has the same general trend, and may be ascribed to faulting. The majority of the streams draining this block, the Makara, Te Awainanga, Te Mata-o-Pakihau, the Mautere, the Mangahau, and the middle part of the Awamata, all flow sub-parallel in the same north-east direction.

The trend-line second in importance is not parallel to any shore-line but gives a noticeably meridional course to many of the streams, as in the upper branch of the Makara, the Tauaropa, the Nairn, and part of the Wairarapa.

A third series of faults trending west-north-west is also indicated. The northern boundary of the block from Waitangi to the east coast north of Owenga is a fault-boundary; in fact it is probable that the sea has broken right across the island along this line. This line

of weakness is also followed by some of the streams, viz., the Tuku-a-Tamatea and the Waipurua. The large Awainanga makes several almost right-angle turns and follows this trend for short distances.

Finally a north-north-west fault-direction is shown by the coast-line from Point Durham to the Horns. This trend is followed in the lower course of the Awamata, and again, after a change to the north-east line, in the upper stretches of the same stream.

Thus the drainage of this area is clearly determined by a series of persistent fractures or lines of weakness. The area affords an excellent example of Hobb's "lattice-drainage."

As illustration, the two largest streams, the Nairn and Te Awainanga, may be taken. The Nairn flows almost due north, but its two main tributaries, the Mangahau and the Mautere, both flow to north-east. Te Awainanga shows the relation of drainage to structure even more fully. Its headwaters (the Tauaropa) flow due north till joined by Te Mata-o-Pakihau which flows to the north-east, the two uniting in the main stream or Te Awainanga, which continues in the latter direction until it turns sharply to the east-south-east, and shortly afterwards is joined by the Makara. This tributary at first flows north, but turns north-east before entering the main stream. Below the junction the main stream also turns north-east before it enters the swamp at Rangihapainga. Hence practically the whole course of both these streams has been determined by fractures which have provided lines of weaknes along which the streams could erode their channels with comparative ease.

Several streams, however, especially in the south-west corner of the block, enter the sea by deep narrow gorges; these streams were in existence prior to the uplift and cut gorges as the land rose.

(b) *Central Limestone Area.*—Over most of this area horizontal limestone either outcrops or immediately underlies the surface deposits. The land is low-lying and calls for no special mention as far as tectonics are concerned.

(c) *Northern Schist Area.*

(1) North-west Peninsula. Over this area the average strike of the schist rocks is about 80° E. (Mag.). It varies within the limits 65° to 102° E. The dip, in the main, is from 28° to 30°, either to the south or the north. These schists then form a series of short-limbed anticlines and synclines.

Dr. Marwick, who kindly noted strikes and dips between Whangatete Bay and Ocean Bay, saw that in one or two localities the strike is extremely variable. An area of great irregularity is on the west side of Whangatete Bay, where there are meridional strikes.

The "fossil-plain," and line of volcanic residuals in this area have already been discussed.

(2) North Central Area. This area is important stratigraphically but gives few tectonic data, except that here we have another centre of violent volcanic activity. The main peaks are Rangitihi, Puhina, and Motuariki. The tuffs, which are extensively developed, show great variation in strike and dip, probably indicating proximity to the centre of eruption.

(3) North-east Schist Area. Schists are found in Waipapa Creek, on the shore of Te Whanga, at Taupeka Point, and from Matarakau to Cape Munning and Okawa. The structure of the area is somewhat complex.

In the main the schists strike, as in the north-west area, in an east-west direction. However, two series of schist rocks are found in the section at Matarakau. The lower consists of blue-grey silky mica-schists which strike east and west, and dip south at 30°. These are overlain by more massive quartz-schists which strike north and dip at 30° to the west. Hence the upper series has been thrust over the lower. The lower series is derived from a mudstone, and is more liable to give way to strain than is the upper. It forms the incompetent member of the series. When faulting occurred, the upper more resistant quartz-schist has been moved over the lower more pliable mica-schist, and the strike has locally been swung round into a north-south line.

From Kaingaroa east to Munning Point and Okawa the quartz-schists strike normally, east and west. Here they are highly tilted and dip to the north at high angles ranging from 65° to 82°.

SUMMARY.

The island group in its present form is due to two factors. Immediately after the faulting that blocked out the main masses, Chatham Island appears to have consisted of four isolated islands. The largest of these was the southern plateau which was separated by an arm of the sea from the north-central area. The old shore-line followed the west coast of the lagoon from Waitangi to Taupeka. Further in the north-east the Kaingaroa block existed as a schist-island, and in the north-west the Cape Pattison area was separated from Maunganui.

The next phase was probably a slight uplift and the formation of the extensive sand-bars which now link up these old land-masses.

Pitt Island seems to be a faulted remnant of a greater Chatham Island, and the 14-mile wide Pitt Strait is clearly a sunken trough, or perhaps an area which failed to rise when faulting occurred. Mangere and Rangatira are but recently separated from Pitt Island.

Taken as a unit the Chatham Island group represents but a small part of a formerly extensive land area.

REFERENCES.

COCKAYNE, L. A Short Account of the Plant Covering of the Chatham Islands. *Trans. N.Z. Inst.*, vol. 34, pp. 243-55, 1901.

DIEFFENBACH, E. Account of the Chatham Islands, *Roy. Geog. Soc. Journ.*, vol. 2, p. 195, 1842.

FLORENCE, R. S. Chatham Island, *N.Z. Official Year Book*, 1900.

FORBES, H. O. The Chatham Islands and their Story. *The Fortnightly Review*, May 1893, p. 669.

ROBERTSON, J. A. Chatham Islands, *Proc. & Trans. Queensland Branch R. Geog. Soc. Australasia*, vol. 5, pp. 72-92, 1890.

SKINNER, H. D. The Morioris of Chatham Islands, *Memoirs of the Bernice P. Bishop Museum*, vol. 9, No. 1, pp. 7-15, 1923.

TRAVERS, H. H. On the Chatham Islands, *Trans. N.Z. Inst.*, vol. 1, pp. 173-180, 1868.

Ordovician Graptolites of North-west Nelson.

By R. A. Keble, Palaeontologist, National Museum, Melbourne, and W. N. Benson, Otago University, Dunedin.

[*Read before the Otago Institute, 11th September, 1928; received by Editor, 3rd October, 1928; issued separately, 25th March, 1929.*]

Plates 104-107.

Contents.

Introduction.

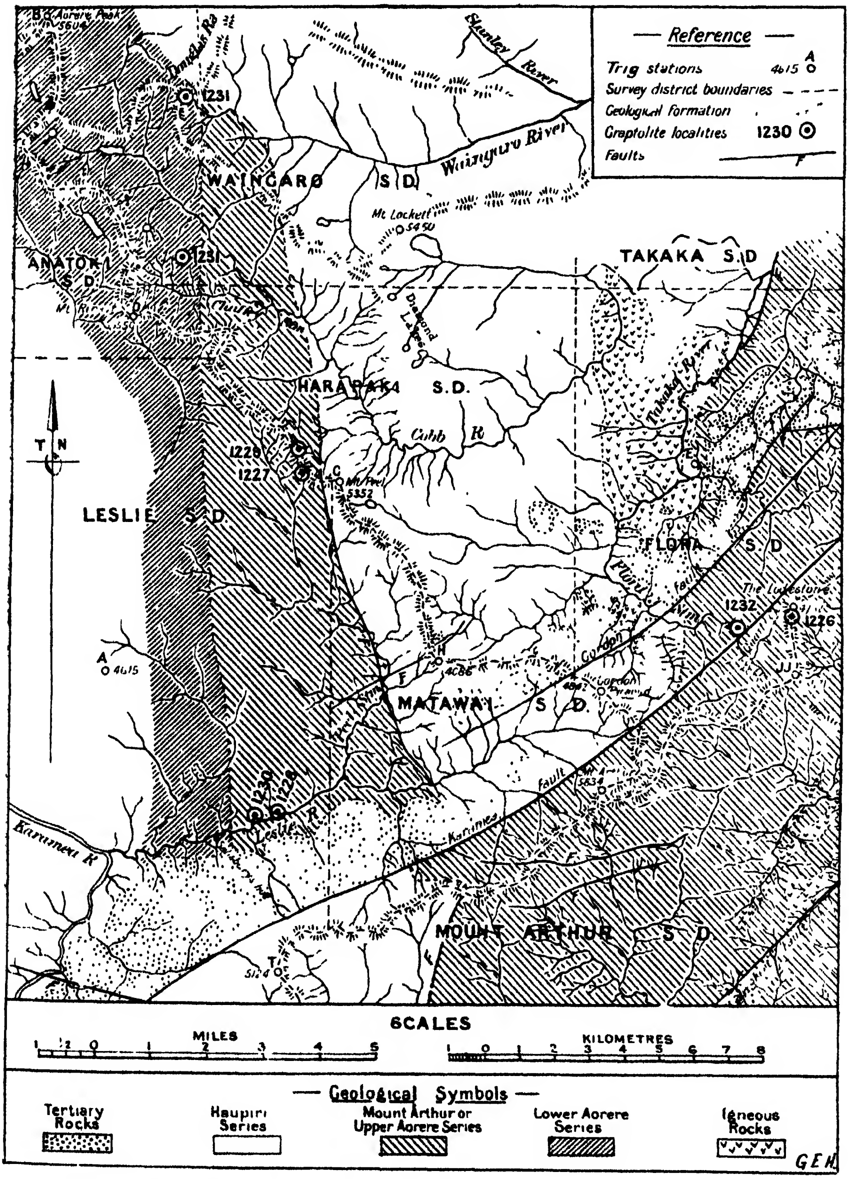
This paper enters into a detailed examination of several graptolite collections from the Motueka and Collingwood subdivisions of the South Island, in regard both to their palaeontological classification and to their sequence, and is, more particularly, an attempt to elucidate the stratigraphical position of the Haupiri Series in regard to the adjoining series.

The collections were made by Messrs. L. I. Grange and E. O. Macpherson of the New Zealand Geological Survey, and Mr. S. J. H. Sylvester of Canterbury College. The Cobb collection (1231) is a very fine one from a bed that is highly important, both palaeontologically and stratigraphically: some of the others, however, are in extremely unyielding matrices, and attest the assiduity and purpose of the collectors.

On account of the difficulty in obtaining additional collections we have figured some imperfect material. It all, however, shows sufficient detail for generic classification.

A representative selection from this material was submitted to one of us (W. N. Benson) by the late Director of the Geological Survey, Mr. P. G. Morgan. Its study indicated the presence of a number of species occurring also in Victoria, but belonging to a higher zone than had yet been recognised in New Zealand. The whole collection was therefore sent for examination to Mr. Keble, who confirmed the earlier work and recognised a number of additional forms. Though the authors collaborated for a time in Melbourne, it should be understood that most of the work recorded herein has been done by Mr. Keble, with whom rests the responsibility for the bulk of the determination and illustration of the species, and all comments on their phylogenetic significance.

We would gratefully express our indebtedness to the late Mr. Morgan for the opportunity of examining these very interesting forms, and to Dr. Henderson, his successor, for the suggestion of appropriate names for the various stratigraphical subdivisions pro-



GEOLOGICAL SKETCH MAP OF THE MOUNT ARTHUR DISTRICT SHOWING GRAPTOLITE LOCALITIES.

posed in the Ordovician system in New Zealand, and for the geological map herewith. To Mr. L. I. Grange we are indebted for notes descriptive of the geological occurrence of the fossiliferous beds.

Problem Stated

Three sets of Palaeozoic beds, which may be distinguished by lithology, form broad meridional belts through the western part of the Motueka Subdivision. The strike of the rocks is north and south, and most of the dips are steeply eastward; there are, however, many exceptions. What has always been regarded as the Aorere Series, the most westerly belt, consists of green and grey argillites and greywackes overlain by dark argillites and shales with thin greywacke bands and lenses of marble. The Cobb graptolites (Coll. No. 1231) are from the dark shale containing thin greywacke bands. They were collected from both sides of the Cobb Valley, and lie about 15 chains above a strong band of quartzite (Sketch Map). The Mount Peel graptolites (Coll. No. 1227 and 1229), which come from shales a little west of Mount Peel, have been regarded on stratigraphical evidence to be a little higher than the Cobb graptolites. The Haupiri rocks, which lie east of the Aorere beds, consist of thick conglomerates, greenstones (metamorphosed igneous rocks), greywacke, and argillite. The eastern belt forming the typical Mount Arthur Series is made up chiefly of marble, phyllites, and dark shales, which in some places are interbedded with greywacke bands similar to those of the western band. These beds contain the Lodestone Peak (Coll. No. 1226) and Flora Track (Coll. No. 1232) graptolites. From the marble farther north a few corals and crinoid stems* have been collected. About 18 miles or so southwestwards of the Lodestone, trilobites were obtained from what are thought to be the Mount Arthur beds. These trilobites have been identified by Dr. Cowper Reed† as Ordovician (perhaps Upper Ordovician).

In the field the evidence is not clear as to the stratigraphical succession of these beds. Two classifications may be drawn up, the youngest formation being on top.

(1)	(2)
Mount Arthur Series	Haupiri Series
Haupiri Series	Mount Arthur Series
Aorere Series	Aorere Series

By the old Survey the Haupiri Series was placed above the Mount Arthur Series. In some places the Haupiri Series rests on what are considered to be portions of the Mount Arthur Series, while in others it appears to underlie them. The investigation of the palaeontological evidence that may throw light on the stratigraphical relationship is the main problem of this paper.

*Dr. Cowper Reed compares the corals with *Palaeopora inordinata* Lonsd., an Ordovician species. The encrinites are indeterminable.

†F. R. Cowper Reed, "New Trilobites from the Ordovician Beds of New Zealand," *Trans. N.Z. Inst.*, vol. 57, pp. 310-14; 1927.

COLLECTIONS AND LOCALITIES.

The following list enumerates the exact localities which have yielded fossils:

Reference in this Paper	Collection No. Geol. Survey	Locality.
Lodestone Peak Bed	1226	Five chains south of Lodestone Peak, head of Graham Stream, Mount Arthur Survey District, Motueka Subdivision. Collectors L. I. Grange and E. O. Macpherson.
Mount Peel, Band A.	1227	Eastern band on ridge, dip west, about 50 chains west-north-west of Mount Peel, on ridge between Peel and Cobb rivers, Harapaki Survey District, Motueka Subdivision. Collector E. O. Macpherson.
Leslie River, Band A.	1228	1¼ mile below Peel Junction, Leslie Survey District, Motueka Subdivision. Collector E. O. Macpherson.
Mount Peel, Band B.	1229	Western band on ridge, dip east, about 70 chains north-west of Mount Peel. ridge between Peel and Cobb rivers, Harapaki Survey District, Motueka Subdivision. Collector E. O. Macpherson
Leslie River, Band B.	1230	1¾ mile below Peel Junction, Leslie Survey District, Motueka Subdivision. Collector E. O. Macpherson.
Cobb Bed	1231	Ridge between Cobb and Waingaro rivers, 1½ miles N.E. of Lake Cobb, Waingaro Survey District, Motueka Subdivision. Collectors L. I. Grange and S. J. H Sylvester.
Flora Track Bed	1232	Flora track, ½ mile north of Quartz Creek, Flora Survey District, Motueka Subdivision. Collector L. I. Grange.
Aorangi Mine Bed	1273	Graphitic slate on tramway between Aorangi Mine and Battery, Golden Ridge, Collingwood Subdivision. Collector E. O. Macpherson.

The positions of all these collections except that of the Aorangi Mine Bed are shown on the Geological Sketch Map herein.

List of Determinations.

The following list enumerates the fossils which have been recognised in the collections from the several localities:—

1226. Lodestone Peak Bed.
Dicellograptus cf. *affinis* T. S. Hall. (2 specimens).
Dicellograptus spp. (10).
Climacograptus missilis Keble & Harris. (2).
Climacograptus cf. *missilis* K. & H. (1).
Climacograptus sp. (1).
Diplograptus euglyphus Lapworth var. *sepositus* K. & H. (3).
Diplograptus cf. *spiculatus* sp. nov. (2).
Diplograptus sp. (7).
Cryptograptus tricornis Carr. (1).
Rest indeterminable.

1227. Mt. Peel, Band A.
Dicellograptus cf. *divaricatus* J. Hall. (3 specimens, 2 figured).
Dicellograptus cf. *elegans* Carr. (2).
Dicellograptus cf. *moffatensis* Carr. (1).
Dicellograptus spp. (8).
Cryptograptus tricornis Carr. (1).
Glossograptus sp. (2).
Climacograptus sp. (3).
Diplograptus cf. *quadrimucronatus* Hall. (1).
Diplograptus cf. *truncatus* Lapw. (2).
Diplograptus spiculatus sp. nov. (2).
Diplograptus cf. *spiculatus*. (1).
Diplograptus euglyphus Lapw. var *distans* K. & H. (3).
Diplograptus cf. *euglyphus* var. *distans*. (1).
Diplograptus semotus sp. nov. (2, Type Fig.).
Diplograptus spp. (19).
Rest indeterminable.

1228. Leslie River, Band A.
Tetragraptus similis ? J. Hall. (1).
Didymograptus sp. (1).
Dichograptid fragments. (5).
Rest indeterminable.

The identification of *T. similis* is somewhat doubtful. Fragments of the Dichograptidae are, however, very common, occurring almost on every slab. The *Didymograptus* is suggestive of the *D. euodus* group. All that may be said is that the horizon is most probably Lower Ordovician.

1229. Mount Peel, Band B.
Dicellograptus sp. (5).
Indeterminable. (1).

1230. Leslie River, Band B.

? Lasiograptus sp. (1).
Dicellograptus sp. (1).
Dicranograptus cf. *rectus* Hopk. (1, Fig.).
Climacograptus sp. (1).
Diplograptus sp. (1).
Biserial forms. (2).
Rest indeterminable.

1231. Cobb Bed.

Didymograptus euodus Lapw. (1, Fig.).
Didymograptus cf. *euodus.* (1).
Didymograptus cf. *superstes* Lapw. (1, Fig.).
Didymograptus cf. *sagitticaulis* Gurley. (1, Fig.).
Didymograptus sagitticaulis Gurley var. *cobbensis* nov. (5, Type Fig.).
Didymograptus caduceus Salter. (1, Fig.).
Didymograptus caduceus Salter var. *spinifer* nov. (1, Type Fig.).
Didymograptus ovatus T. S. Hall. (3, Fig.).
Didymograptus sp. (4).
Tetragraptus tabidus sp. nov. (1, Type Fig.).
Tetragraptus cf. *tabidus.* (2).
Tetragraptus (?) *insuetus* sp. nov. (6, Type Fig. and two others).
Azygograptus prolixus sp. nov. (1, Fig.).
Cryptograptus tricornis Carr. (8, Two Fig.).
Cryptograptus sp. (2).
Glossograptus hincksii Hopk. (12, Eight Fig.).
Glossograptus cf. *hincksii.* (2).
Glossograptus cf. *hermani* T. S. Hall. (1).
Glossograptus acanthus Elles & Wood. (1, Fig.).
Glossograptus villosus sp. nov. (3, Three Fig.).
Glossograptus sp. (13).
Lasiograptus sp.
Retiograptus speciosus Harris. (10, Three Fig.).
Retiograptus cf. *speciosus.* (1).
Retiograptus latus sp. nov. (1, Type Fig.).
Retiograptus cf. *geinitzianus* J. Hall. (1).
Retiograptus sp. (7).
Syndyograptus artus sp. nov. (2, Fig.).
Syndyograptus cf. *pecten* Ruedemann. (1, Fig.).
Leptograptus flaccidus J. Hall var. *angustus,* K. & H. (1, Fig.).
Leptograptus sp. (3).
Climacograptus missilis K. & H. (10).
Climacograptus cf. *missilis.* (1).
Climacograptus cf. *antiquus* J. Hall. (3, Fig.).
Climacograptus sp. (9).
Diplograptus cf. *quadrimucrmonatus* J. Hall. (1).
Diplograptus spiculatus sp. nov. (29, Four Fig.).
Diplograptus cf. *spiculatus.* (3).

Diplograptus euglyphus Lapw. var. *sepositus* K. & H. (24, Four Fig.).
Diplograptus cf. *euglyphus.* (2).
Diplograptus euglyphus Lapw. var. *coitus* nov. (1, Type Fig.).
Diplograptus cf. *teretiusculus* His. (1).
Diplograptus cf. *perexcavatus* Lapw. (1, Fig.).
Diplograptus spp. (11).
Sponge spicules. (1).
Trilobite fragment (?). (1).
Rest indeterminable.

1232. Flora Track Bed.
Didymograptus cf. *sagitticaulis* Gurley. (1).
Cryptograptus tricornis Carr. (1).
Cryptograptus sp. (1).
Glossograptus sp. (1).
Dicellograptus spp. (3).
Dicranograptus sp. (1).
Climacograptus bicornis J. Hall. (1).
Diplograptus cf. *euglyphus* Lapw. var. *sepositus* K. & H. (4).
Diplograptus cf. *spiculatus* sp. nov. (1).
Diplograptus spp. (5).

1273. Aorangi Mine Bed.
Didymograptus nitidus J. Hall var. *aorangiensis* nov. (1, Fig. Fig.).
Didymograptus mundus T. S. Hall. (2, Fig.).
Didymograptus caduceus Salter mut. (3).
Didymograptus caduceus Salter var. *manubriatus* T. S. Hall. (2, Fig.).
Didymograptus sp. (2).
Dichograptus octobrachiatus J. Hall. (2, Fig.).
Dichograptus cf. *octobrachiatus.* (1).

SYNOPTIC TABLE.

	Lodestone Peak Beds	Mt Peel, Band A *	Leslie River, Band A	Mt Peel Band B	Leslie River, Band B	Cobb Beds	Flora Track Beds	Aorangi Mine Beds
	1226	1227	1228	1229	1230	1231	1232	1278
Didymograptus nitidus J. Hall								x
Didymograptus mundus T. S. Hall								x
Didymograptus caduceus, Salter						x		x
Didymograptus caduceus var. *manubriatus* T. S. Hall								x
Didymograptus caduceus var. *spinifer* n. var.						x		
Didymograptus ovatus T. S. Hall						x		
Didymograptus euodus Lapw.						x		
Didymograptus cf. *superstes* Lapw.						x		
Didymograptus cf. *sagitticaulis* Gurley						x	x	
Didymograptus sagitticaulis var. *cobbensis* n. var.						x		
Didymograptus spp.			x					
Tetragraptus similis (?) J. Hall			x (?)					
Tetragraptus tabidus n. sp						x		
Tetragraptus (?) *insuetus* n. sp.						x		
Dichograptus octobrachiatus J. Hall								x
Azygograptus prolixus n. sp.						x		
Cryptograptus tricornis Carr	x	x				x	x	
Leptograptus flaccidus J. Hall var. *angustus* K. & H.						x		
Syndyograptus artus n. sp.						x		
Syndyograptus cf. *pecten* Ruedemann						x		
Dicellograptus cf. *divaricatus* J Hall		x						
Dicellograptus cf. *elegans* Carr		x						
Dicellograptus cf. *affinis* T. S. Hall	x							
Dicellograptus cf. *moffatensis* Carr		x						
Dicellograptus spp.				x	x		x	
Dicranograptus cf. *rectus* Hopk.					x			
Glossograptus hincksii Hopk.						x		
Glossograptus cf. *hermani* T. S. Hall						x		
Glossograptus acanthus E. & W.						x		
Glossograptus villosus n. sp.						x		
Glossograptus sp.		x				x	x	
Lasiograptus sp.					x (?)	x		
Retiograptus speciosus Harris						x		
Retiograptus latus n. sp.						x		
Retiograptus cf. *geinitzianus* J. Hall						x		
Climacograptus missilis K. & H.	x					x		
Climacograptus cf. *antiquus* J. Hall						x		
Climacograptus bicornis J. Hall							x	
Climacograptus sp.		x			x			
Diplograptus euglyphus Lapw. var. *sepositus* K. & H.	x	x				x	?	
Diplograptus euglyphus var. *coitus* n. var.						x		
Diplograptus spiculatus n. sp.	x ?	x				x	?	
Diplograptus cf. *quadrimucronatus* J. Hall		x				x		
Diplograptus cf. *truncatus* Lapw.		x						
Diplograptus semotus n. sp.		x						
Diplograptus cf. *teretiusculus* His.						x		
Diplograptus cf. *perexcavatus* Lapw.						x		
Diplograptus sp.					x		x	

Palaeontological Sequence.

The Aorangi Mine Bed (Coll. No. 1273) is considerably older than any bed represented in the other collections. It is the equivalent of Subzone C.1. of the Castlemaine zone of Victoria, there at least 8000 feet below the Turner's quarry beds, the Victorian equivalent of the Cobb Bed (Coll. No. 1231).

The Leslie River Band A (Coll. No. 1228) is certainly lower than the Cobb bed (Coll. No. 1231), but precisely how far below is not clear from the imperfect preservation of the collection. If, as we think, the *Didymograptus euodus* group occurs in this bed, then it would be relatively close to the Cobb bed and considerably higher than the Aorangi Mine Bed. It probably indicates the presence of an anticlinal or faulted inlier of Lower Ordovician beds among the Upper Ordovician rocks.

The Cobb Bed association (Coll. No. 1231) is near the top of the Lower Ordovician. This highly fossiliferous bed should afford a very definite bench-mark in separating the Lower from the Upper Ordovician, particularly if the quartzite band a little to the west is a persistent feature. The line of demarcation between the Lower and Upper Ordovician lies to the east of the Cobb Bed.

The Upper Ordovician is made up of three known beds. Undoubtedly resting conformably on the Cobb Bed (No. 1231) and with several common forms, is the Mount Peel Band B (Coll. No. 1229). About the same horizon as the Mount Peel Band B is the Mount Peel Band A (Coll. No. 1227), and the Lodestone Peak Bed (Coll. No. 1226).

The Flora Track or *Climacograptus bicornis* bed (Coll. No. 1232) is higher than, but conformable to, the Mount Peel Bands. The only fairly definite species in the Leslie River Band B. (Coll. No. 1230) is *Dicranograptus* cf. *rectus,* but the genus is indubitable. The collection is small and this is the only bed from which *Dicranograptus* gen. has been recorded. In Victoria* the Dicranograptidae characterize subzones above the *C. bicornis* subzone, and occur sparingly with *C. bicornis* towards the close of the latter's range. There is little doubt that the Leslie River *Dicranograptus* Bed rests conformably on the Flora Track Bed.

Proposed Subdivision of Lower and Upper Ordovician Rocks.

The following table showing a tentative subdivision of the broad belts of strata flanking the Haupiri Series on the east and west, that is, of the Aorere Series, is based on a comparison with the sequence of Ordovician graptolitic beds in Victoria, and is submitted as a working hypothesis. In order to increase its usefulness, the opportunity is taken to include also the graptolite-bearing beds of Western Southland, so that the table summarizes all the available data concerning the graptolitic rocks of New Zealand, and indicates what additional zones may eventually be found.

*Harris, W. J. and Crawford, W., The Relationships of the Sedimentary Rocks of the Gisborne District, Victoria. *Proc. Roy. Soc. Vict.*, vol. 33 (N.S.), 1921. On p. 53 a broad subdivision of the Upper Ordovician is given.

TENTATIVE SUBDIVISION AND CORRELATION OF NEW ZEALAND AND AUSTRALIAN GRAPTOLITE STRATA.

NEW ZEALAND						AUSTRALIA.		
Series	Zone	Index Forms		Sub Zone	Index Forms.	Zone	Sub Zone.	Remarks
Early Lower Ordovician No. Series name suggested at present.	PRESER- VATION.	Appearance of *Staurograptus* gen. to extinction *T. decipiens* and *T. approximatus* which range into the next zone to appearance of *T. fruticosus.*	d	Not yet known in N.Z.	*Clonograptus* spp. *Bryograptus* spp. *Staurograptus* gen. to extinction	LANCE- FIELD	L. 4.	See Notes A and B below.
			c	(1) Preservation Inlet Beds.	*C. tenellus* *C. tenellus* var. *callavei* *C.* spp. *B.* spp. *Tetragraptus* *decipiens* to appearance of *T. approximatus*		L. 3.	
			b	Not yet known in N.Z.	(*T. Approximatus* *T. decipens* *C. tenellus*			
			a	Not yet known in N.Z.	*C.* spp. *B.* spp. *Didymograptus* spp.)		L. 2. L. 1.	
	Not yet known in N.Z.	*T. fruticosus.* Appearance to extinction.	e	Not yet known in N.Z.	(*T. fruticosus* *T. approximatus* *T. decipens*	BENDIGO	B. 5.	
			d c b a	Not yet known in N.Z.	*C.* spp. *B.* spp. *T. fruticosus* *D. bifidus* *C.* spp.)		B. 4. B. 3. B. 2. B. 1.	
Lower Aorere	GOLDEN RIDGE.	The dependent *Didymograpti* (*D. bifidus, D. nanus,* etc.) without *Tetragraptus fruticosus* become extinct above this zone.		Band B. Slaty Ck. (2) Cape Provi- dence. (3)	*D. bifidus* and *D. nanus.* The above with *D. caduceus* et mut.	CASTLE- MAINE.	WATTLE GULLY.	
		The reclined *Didymograpti* (*D. caduceus* et mut.) appear before the dependent *Didymograpti* become extinct, and range beyond this zone.		Band A. Slaty Ck. (4)	Reclined *Didymograpti*		VICTORIA GULLY.	
				Aorangi Mine (5)	Reclined *Didymograpti,* *D. caduceus* var. *manubriatus,* but no *Oncograptus*		McKENZIE HILL. (Upper Part.)	
	DOUGLAS	*Oncograptus* gen. which outruns *D. caduceus* var. *manubriatus* appears rarely and overlaps the lower range of *Cryptograptus* *tricornis* which extends into the Mount Arthur Series.		Not yet found in N.Z.		DARRI- WIL (6)	WOODBROOK ROAD CASTLE- MAINE McIVOR RD. BENDIGO E. BENDIGO E.	See Note C below.
		The reclined *Didymograpti,* of which the last is *D. ovatus* range throughout this zone. The extinction of *Tetragraptus* gen. marks the close of the Lower Ordovician.		Cobb (7)	*D. caduceus* *D. ovatus* *Diplograptus* *spiculatus* *Cryptograptus* *tricornis*		TURNER'S QUARRY. BITTERN	

Mount Arthur or Upper Aorere	LODESTONE	*C. tricornis* and *D. spiculatus.* The *Dicellograpti* appear above the base, and continue with *D. spiculatus* and after it becomes extinct, *C. tricornis* still continues. The extinction of *Climacograptus bicornis*, which appear about the time *D. spiculatus* becomes extinct, marks the close of the Lodestone Zone.		(*D. spiculatus* and *D. ovatus*)	SANDY'S CK. (8)
				(*D. spiculatus* no *D. ovatus* no *Dicellograpti*)	
			Mt. Peel (9)	*D. spiculatus* and *Dicellograpti*	DARK RIVER (10)
			Flora Track (11)	*C. bicornis* no *Dicellograpti*	YARRA TRACK (12)
	LESLIE	From the appearance of the Dicranograptidae to the appearance of the Monograptidae.	Leslie River (13)	*Dicranograptus*	MT. EASTON (14) (*Dicranograptus* beds) JERICHO

NOTE A.—In this table the terms "Aorere," "Preservation," and "Preservation Inlet" have been employed as series, zonal, and subzonal names respectively in a manner which seems to accord with their original usage, and the distribution of the rocks they denote. They have, however, been confused since their first application. Thus Park (18) in 1910 extended the term "Kakanui (Aorere)" to cover all the Ordovician rocks in New Zealand, and Marshall (19) and later writers have employed "Aorere" in a similar manner. Subsequently Park (20) used the term "Preservation Inlet Series" to denote all the slaty argillites and schistose greywackes of his Kakanui (Aorere) Series in Western Southland, specifically including in these the rocks of Chalky Inlet (Cape Providence) and Preservation Inlet. The discovery (3) that the Cape Providence beds belong to a horizon which, in Victoria is about 15,000 feet stratigraphically above the horizon represented by the graptolitic beds at Preservation Inlet, makes desirable their nomenclatural separation.

NOTE B.—Provision is made for the addition, when discovered, of a basal sub-zone (or equivalent to the *Dictyonema flabelliforme* subzone of Europe and America. This subzone is regarded by British geologists as marking the close of the Cambrian, but by others in Europe and America as ushering in the Ordovician transgression (15, 16). It is known that *Staurograptus* gen is in its lower range, associated with *Dictyonema*, and in its higher range, with a fauna similar to that of Preservation Inlet. There is reason for suspecting that the form from Preservation Inlet figured by T. S. Hall as *Bryograptus* (17) may actually belong to the genus *Staurograptus*. It is confidently assumed that the *T. approximatus* beds when found will be capable of subdivision.

NOTE C.—Victorian subzonal associations probable in the Douglas Zone are *O. upsilon* and *D caduceus* var *manubriatus* (Woodbrook Road, Castlemaine); *Oncograpti, C. tricornis*, and *D. caduceus* (McIvor Road, Bendigo East); *C. tricornis* without *Oncograpti* (Bendigo East); and *D. ovatus, C. tricornis*, and *D. caduceus* (Turner's quarry).

REFERENCES CITED IN ABOVE TABLE AND NOTES.

1. Hall, T. S. The Occurrence of Lower Ordovician Graptolites in Western Otago. *Trans. N.Z. Inst.* vol. 47, 1914, pp. 410-1.
2. Shakespear, Ethel M. R. On Some New Zealand Graptolites, *Geol. Mag.* (N.S.) Dec. 5, vol. 5, pp. 145-48, 1908.
3. Keble, R. A. Graptolites from Cape Providence, Chalky Inlet, Southland, *Trans. N.Z. Inst.*, vol. 58, pp. 157-59, 1927.
4. Shakespear, Ethel M. R. *Supra cit.* Also Hall, T. S., The Golden Ridge Graptolites *Trans. N.Z. Inst.*, vol. 47, 1914, pp. 411-3.
5. Coll. No. 1273.
6. Harris, W. J. The Palaeontological Sequence of the Lower Ordovician Rocks in the Castlemaine District, *Proc. Roy. Soc. Vict.*, vol. 29, (N.S.) p. 55, 1916.
7. Coll. No. 1231.
8. Hall, T. S. Reports on Graptolites, *Rec. Geol. Surv. Vict.*, vol. 1, pt. 1, pp. 33-34, 1902. Further collecting has shown that the fauna is larger than listed in this report.
9. Coll. Nos. 1226, 1227, and 1229.
10. *D. spiculatus* is recorded in MS. report on Dark River.
11. Coll. No. 1232.
12. Keble, R. A. and Harris, W. J. *Graptolites* from Mt. Easton, *Rec. Geol. Surv. Vict.*, vol. 4, pt. 4, locs. 10 and 18, pp. 510-11, 1925.
13. Coll. No. 1230.
14. Keble, R. A. and Harris, W. J. *Supra cit.* loc. C., p. 511.
15. Ruedemann, R. Palaeontological Contributions from the New York State Museum, 16th Report of the State Mus. and Science Dept. Bull. 227, 228 (1919) pp. 118-9. Ruedemann concludes his remarks on the *O. flabelliforme* zone with the following: ". . . . it has been recognised in Europe especially through Moberg's work, from the accompanying biota, that the *Dictyonema* shale introduces an extensive Ordovician transgression and therefore is properly considered the base of that series."
16. Harris, W. J. and Keble, R. A. The *Staurograptus* Bed of Victoria. *Proc. Roy. Soc. Vict.*, vol. 40, pt. 2 (N.S.) 1928, p. 94.
17. cf. Fig. 5, Plate VIII, *Trans. N.Z. Inst.*, vol. 47.
18. Park, J. *The Geology of New Zealand*, Whitcomb and Tombs, Christchurch, 1910, pp. 29-38.
19. Marshall, P. New Zealand and adjacent Islands. *Handbuch der regionalen Geologie*, Carl Winter, Heidelberg, 1912, pp. 12-14.
20. Park, J. The Geology and Mineral Resources of Western Southland, *Geol. Survey, New Zealand Bull.* 23, 1921, pp. 33-38.

Owing to the fact that Victorian palaeontologists have some difficulty in specifically separating the dependent group of *Didymograptus* in the Australian region, we have, in this tentative subdivision, used them as a group. Similarly we have used the reclined group as a group, knowing that a revision of *Didymograptus caduceus* with its many mutations is urgently required. In fixing *D. caduceus* var. *manubriatus* as the concluding subzonal form of the Golden Ridge zone, we are guided by the facts, (a) that it is readily recognized by its abnormal sicula; (b) that it comes into the succession at a time that divides the upper portion of the Lower Ordovician into two approximately equal periods; and (c) that, if the beds can be found, the next highest subzone should contain *Oncograptus* making the Douglas zone start at approximately the same horizon as the Victorian Darriwil zone, an eminently satisfactory basis for comparison.

The extinction of *Tetragraptus* gen. is generally regarded as marking the close of the Lower Ordovician and, incidentally, the close of the Douglas zone. Its extinction is not always easy to prove on account of its rarity and gerontic attenuation, which makes for fragmentary and poor preservation. With such an associate as *D. ovatus* which has a slightly higher range, and other characteristic associates in the uppermost bed, the task is somewhat simplified.

The succession from the Cobb to the Mount Peel subzone is apparently quite conformable. All the species that will enter into a subdivision of the intervening beds are recorded in the Cobb (Coll. 1231) and the Mount Peel collections (1231, 1227, 1229). The subzonal forms will probably be found to be *Didymograptus ovatus*, *Azygograptus prolixus*, and the several species of *Leptograptus*, *Retiograptus*, *Syndyograptus*, and *Glossograptus*. We have, in the tentative subdivision, suggested subzones known to have Victorian equivalents.

Climacograptus bicornis, the index form of the Flora Track subzone is readily recognized, as are also the *Dicranograptidae*.

CONCLUSION.

From what has been said above it is obvious that the rocks occurring east and west of the broad belt of Haupiri Series belong to the same group of strata. The sequence of faunas shows that the beds were deposited, if not continuously, at least without any considerable stratigraphical break. Clearly the Haupiri rocks, which are of vast thickness, cannot be included as part of the sequence from which the graptolites considered in this paper were obtained. Probably they owe to folding or faulting their position between belts of Ordovician strata differing little in age.

DESCRIPTION OF SPECIES.

Family—DICHOGRAPTIDAE.

Genus—DIDYMOGRAPTUS.

Didymograptus nitidus J. Hall var. **aorangiensis** n. var. (Fig. 1).

In the Aorangi Mine specimens the branches arise at an angle slightly less than 180° but about Th 7 assume a greater angle. Sicula

slightly more than 1.0 mm. long. Thecae number 12 in 10 mm., overlap one-half their length proximally, and distally two-thirds; they are inclined at an angle of from 25° to 35°. Apertural margin straight or slightly concave and normal to thecal axis; ventral margin straight.

Proximal width of branch, 0.3 mm., less than that given by Elles & Wood,* viz. 0.87 mm. for British forms of *D. nitidus;* maximum width observed, 1.1 mm., is relatively near sicula. Angle of inclination of thecae is, too, less than in British forms. There appears to be little doubt, however, that the Aorangi Mine form has close affinities to *D. nitidus* and agrees well except where indicated; to mark these differences, therefore, we have made a varietal distinction.

Associates—*D. nitidus* var. *aorangiensis* has as associates *D. mundus, D. caduceus, D. caduceus* var. *manubriatus, Dichograptus separatus, D.* cf. *octobrachiatus.*

Horizon—Lower Aorere Series, Zone-Golden Ridge, Subzone-Aorangi Mine.

Didymograptus mundus T. S. Hall. (Fig. 2).

Hall, T. S., Vic. Grap., *Proc. Roy. Soc. Vict.*, vol. 27, p. 107, Fig. 9.

Branches diverge from sciula at angle of 102° and curve to Th 6 when they become approximately horizontal. Maximum length observed is slightly more than 40 mm. and width near sicula is between 0.3 and 0.5 mm. Sicula 1.5 mm. long.

Proximal thecae number 8 in 10 mm., overlap one-half their length and are more than twice as long as wide; they are slowly expanding and inclined at an angle of from 40° to 50°. Outer extremity forms an acute denticle.

The Aorangi Mine specimens agree in all particulars with T. S. Hall's description.

Horizon—Lower Aorere Series, Zone—Golden Ridge, Subzone—Aorangi Mine.

Didymograptus cf. **sagitticaulis** Gurley. (Fig. 3).

Ruedemann, R. Graptolites of New York, *New York State Mus.*, Mem. No. 11, pt. 2, pp. 247-251, Fig. 151-155 emend.

In the polypary of the New Zealand specimen the branches diverge from the sicula at 45° or more (sicula not visible) but attain approximate horizontality within 10 mm., a width of 0.7 mm. within 2.0 cm. and 1.0 mm. within about 5.0 cm. from the sicula.

Thecae in proximal portion of specimen 7 or 8 in 10 mm., inclined at an angle of from 15° to 20°, overlapping one-quarter their length, 6 or 7 times as long as wide; in distal portion 6 or 7 in 10 mm., inclined at an angle from 20° to 25°, overlapping one-half their length, 6 or 7 times as long as wide, ventral margin straight or slightly concave, apertural margin straight, normal to axis of theca.

*Elles, Gertrude L., and Wood, Ethel M. R., British Graptolites pt. 1, p. 10, *Palaeon. Soc.*, vol. 55.

This differs from Ruedemann's description in (a) a dorso-concave as compared with a dorso-convex curvature of branches near sicula, (b) ventral margins of thecae straight as compared with straight or slightly convex margins in American forms. How far these differences are attributable to the direction of compression is difficult to judge, but there is a close agreement between the two forms, and if the sicula were not missing in the New Zealand specimen we would have no hesitation in relegating it to *D. sagitticaulis* without reservation.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Didymograptus sagitticaulis Gurley var. **cobbensis** n. var. (Figs. 4a-c).

Polypary declined, but branches passing from gentle dorso-concave curvature into relative straightness, 0.3 mm. wide near sicula, gradually widening to 0.5 mm. at about Th. 16, but maximum width not known. Sicula small, about 0.5 mm. long and 0.3 mm. broad. Thecae number 12 or 13 in 10 mm. in proximal portion, and 11 in distal portion. Proximal thecae about 1.2 mm. long and 0.5 mm. wide with straight apertural margins normal to axis of branch, ventral margins concave, twice as long as broad, overlapping one-fourth their length or less and inclined at angle of 25°. Ventral margin straightens as polypary develops and with the oblique apertural margin forms a distinct denticle. The most distal thecae observed are 1 8 mm. long and 0.6 mm. wide, more than twice as long as broad, overlap one-half their length, and are inclined at an angle of 20°.

The first thecae originate near the apex of the sicula and diverge below the parture. The species differs from *D. sagitticaulis* in the proximal curvature of the branches, closer set of thecae in the more distal portions, the point of divergence of the branches, and in other minor respects, but there is little doubt regarding its affinity; these differences are, perhaps, regional but we think they merit a varietal distinction.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Didymograptus cf. **superstes** Lapw. (Fig. 5)

Elles, Gertrude L., and Wood, Ethel M. R., British Graptolites pt. 1, *Palaeon. Soc.*, vol. 55, p. 19-21, plate 1, figs. 9 a. b., text figs. 11 a. b. c.

In the Cobb River collection there occurs a sicula and proximal portion of a *Didymograptus* which we think may be correlated with this species. Branches 0.3 mm. wide near sicula from which they diverge at wide angle but subsequently become straight; at Th 6 they attain a width of approximately 1 mm. Thecae number 5 or 6 in 10 mm., are twice as long as broad, overlap slightly in the proximal portion and about one-fourth their length at Th 6. Ventral margin irregularly concave, inclined at angle of 30°, apertural margin straight or slightly concave, lying at angle of from 140° to 150° to axis of branch. Sicula small and inconspicuous probably with nema. Unfortunately the sicula is somewhat indistinct and the distal portions of the branches are missing.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Didymograptus euodus Lapw. (Figs. 6a-c).

Lapworth, C., *Quart. Journ. Geol. Soc.*, vol. 31, p. 645, Pl. 35, Fig. 1a-c.

In the New Zealand form the sicula is 1.1 mm. long and 0.5 mm. wide. Thecae number 8 or 9 in 10 mm., are four or five times as long as broad, overlap one-half their length proximally, and from one-half to two-thirds distally, inclined at angle of from 20° to 30° (distally). Ventral margin with shallow double curvature, apertural margin straight or slightly concave. Minimum width near sicula 0.5 mm., maximum width 1.5 mm.

Owing to distortion the appearance of the sicula in the only specimen (Fig. 6b), where it is visible is unusual. It has the appearance of having two openings, an aperture corresponding to the normal one and a subangular one near the apex. The normal aperture is circular and has the appearance of opening from the side of the sicula. The whole sicula has been reversed and were it not for the traces of a nema one would have difficulty in distinguishing its apical from its apertural region. The points of origin of the first thecae are obscure.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Didymograptus caduceus Salter. (Fig. 7).

Salter, J. W. (pars), *Quart. Journ. Geol. Soc.*, vol. 9, p. 87, Fig. 1a.

Branches about 5 mm. long, decreasing from a width of 1.5 mm. at sicula to 1.0 mm. at distal end. Sicula 2.0 mm. or more in length. Thecae 16 in 10 mm., curved, inclined to axis of branch at about 45°, two to three times as long as wide, in contact two-thirds their length. Apertural margins concave.

The variability of this species is clearly shown by tabulating the several dimensions from Elles & Wood's, Ruedemann's and the New Zealand forms—

		New Zealand sp.	America*	Britain†
Branches	Width at sicula	1.5	2.2	2.1
	Width at end	1.0	1.1	—
Sicula		long, very slender	long and slender	long and slender
Thecae	Angle of ventral margin	45°	45°	45°
	Length to breadth	3 : 1	3 : 1	4 : 1
	Overlap	$\frac{1}{3}$	none	none
	Apertural margin	concave, conspicuously mucronate or spinous	concave, mucronate	concave
	Number in 10 mm.	12-13	11-14	16

Horizon—Lower Aorere Series, Zones—Golden Ridge and Douglas, Subzones—Cape Providence to Cobb (incl.).

*Ruedemann, R. *Grap. of New York, New State Mus.*, Mem. 7, pp. 693-8.

†Elles, Gertrude L. and Wood, Ethel M. R. Brit. Grap., pt. 1, p. 52-4. *Palaeon. Soc.*, vol 55.

Didymograptus caduceus Salter var. **manubriatus** T. S. Hall. (Fig. 8).

Hall, T. S. *Proc. Roy. Soc. Vict.*, vol. 27 (N.S.), pt. 1, pp. 108-9, Pl. 17, Fig. 12 and 13.

T. S. Hall states that *D. caduceus* var. *manubriatus* "differs from the typical form by the immense size of the sicula, which at the point of separation of the branches is as wide as the branch itself. Thecae 10 in 1 cm. Branches diverging at 130° to 140° and varying from 2 to 3 mm. in width."

The dimensions tabulated with those of the New Zealand form are as follows:—

	Victorian Species.	New Zealand Species.
Sicula	as wide as branch at divergence, conical	not quite as wide as branch, tapering
Thecae in 10 mm.	?	13-14
Branches		
Divergence	130°-140°	100°
Width	2-3 mm.	1-2 mm.

Before accepting these differences it would be advisable to compare a number of more mature New Zealand forms, particularly as T. S. Hall* says that "there is a considerable range in width of the branches and the angle of divergence, but the great size of the sicula is remarkable."

Horizon—Lower Aorere, Zone—Golden Ridge and probably Douglas, Subzone—Aorangi Mine and next subzone above.

Didymograptus caduceus Salter mut. **spinifer** n. mut. (Fig. 9.)

Branches long, over 40 mm., decreasing in width and forming a polypary, the contained angle of which falls within 25°. Sicula about 1.5 mm. long.

Thecae 12 to 13 in 10 mm., curved, inclined to axis of branch at angle of from 25° to 35° (distally), from three to four times as long as wide, in contact for more than three-fourths their length, ventral margins, concave, apertural margins, concave in proximal thecae, each produced into a more or less conspicuous spine or mucro.

This is one of the many mutations of *D. caduceus* that call for a revision of the species. It differs from the typical species in (*inter alia*) (a) the smaller inclination of the thecae, and, (b) the smaller contained angle of the polypary, and (c) the spinous nature of the proximal thecae. Differences (a) and (b) are concomitant and may be of some phylogenetic value as they foreshadow the concrescence of the branches in such a genus as *Cardiograptus*.†

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

**Supra cit.*

†Harris, W. J., The Palaeontological Succession of the Lower Ordovician Rocks in the Castlemaine District, *Proc. Roy. Soc. Vict.*, vol. 29 (N.S.), pt. 1 (1916), Pl. 1, Fig. 1-3.

Didymograptus ovatus T. S. Hall. (Fig. 10).

Hall, T. S., *Rec. Geol. Surv. Vict.*, vol. 1, pt. 1, p. 33, Fig. 1.

T. S. Hall's description was as follows:—"Hydrosome [Polypary] stout, branches abruptly recurved and gradually approaching one another . . . . . Branches of a uniform width of 1.0 mm. or to the top of the mucronate extensions of the thecae about 2.0 mm. Sicula long and slender with a delicate virgula. Thecae curved, expanding, about 0.5 mm., overlapping by one-half their length, and at a distance of about 10 mm. from the sicula inclined at an angle of 40°; outer margin curved; apertural margin deeply concave, and produced so as to make, with the outer margin, a stout, spinose, mucronate extension of about 1.0 mm. in length. Thecae numbering 12 in 10 mm."

The New Zealand form is much more robust than the Victorian but is, at the same time, not so long and does not show the recurvature. Sicula short (2.7 mm.) and broad (2.0 mm.); there is no nema (virgula). Thecae wider, overlap two-thirds their length, are inclined distally about 45°, and have spines up to 2.0 mm. in length. Thecae number 9 in 10 mm. Most of these differences are merely relative and there is little doubt that the form from Cobb River is the regional equivalent of the Victorian form. Further collections from Sandy's Creek made by the Victorian Geological Survey since Hall described *D. ovatus* in 1901, contain forms of *D. ovatus* markedly similar to the New Zealand form in an association that is almost identical.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb; also probably ranging up into the Mount Arthur Series.

Associates—In the Cobb subzone *D. ovatus* is the index species with *Tetragraptus* gen. In the Mount Arthur Series it occurs without *T.* gen.

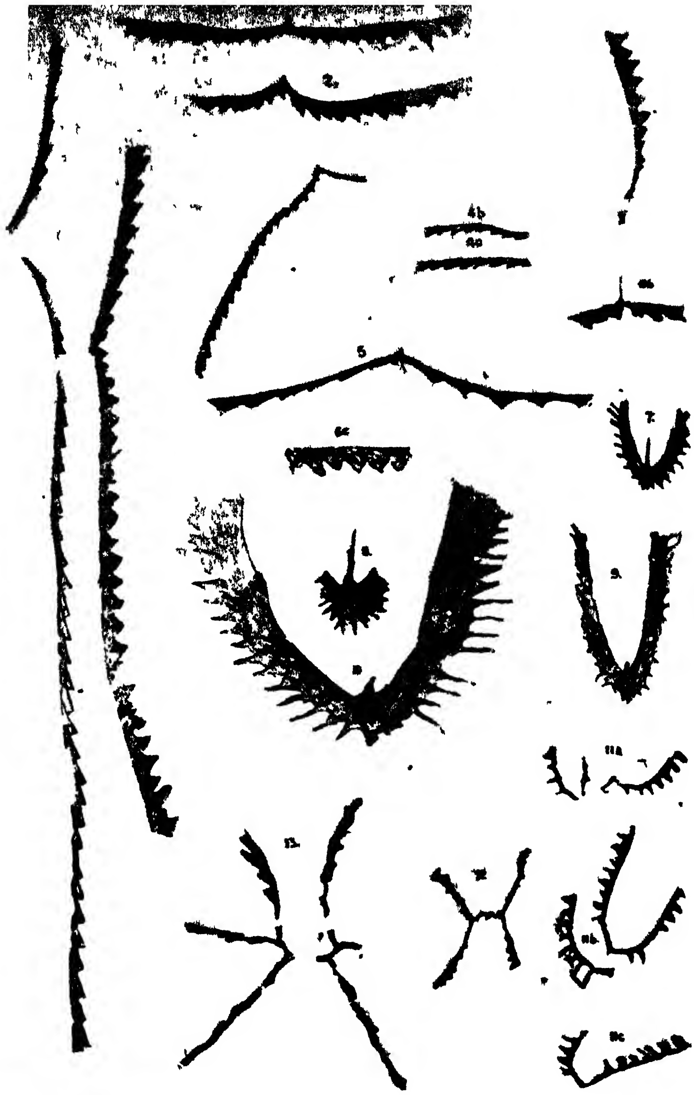
Genus—TETRAGRAPTUS.

Tetragraptus (?) **insuetus** n. sp. (Figs. 11 a-c.)

Shape of polypary unknown, but almost certainly one in which dichotomy up to the second order has taken place. Branches usually exhibit a dorsal curvature. Sicula not seen. Thecae suggestive of the *Monograptus* type, 12 or 13 in 10 mm., aperture normal to axis of branch or slightly everted and prolonged into a broad spine; ventral margin with a slight sigmoidal curvature. Overlap slight.

Like *Monograptus T. insuetus* sometimes shows torsion of thecal axis (Fig. 11c). Apertures seen on left hand branch (Fig. 11c) while on the other branch apertural termination is blunted in more proximal thecae and almost entirely concealed in distal thecae. On the other hand, all thecae of one branch (Fig. 11b) are more or less spinous while on other branch of same polypary ventral walls are absent only, the thickened apertural margin with its spinous termination being preserved and suggestive of some forms of Rastrites.

The generic position of *T. insuetus* is doubtful. As yet we have only seen portions of the polypary which show, however, with tolerable certainty that the form branches by simple dichotomy. The unique features of the form are too important phylogenetically to pass over, particularly as a complete polypary of such a compara-



(All figures twice natural size).

Fig 1 *Didymograptus nitidus* J Hall var *aorangiensis* var. nov. Loc No. 1273. Polypary

Fig 2 *D. mundus* T. S. Hall, Loc. No. 1273. Polypary

Fig. 3. *D* cf. *sagitticaulis* Gurley, Loc No 1231 Branches, sicula missing

Fig 4. *D sagitticaulis* Gurley var. *cobbensis* var nov. Loc. No. 1231.
a. Polypary c Distal thecae.
b Proximal thecae.

Fig. 5 *D* cf *superstes* Lapw., Loc. No. 1231. Proximal portion

Fig. 6 *D. euodus* Lapw., Loc. No 1231.
a. Polypary b. Thecae of proximal portion.
c. Distal thecae.

Fig 7. *D. caduceus* Salter, Loc. No. 1231. Polypary.

Fig. 8. *D. caduceus* Salter var. *manubriatus* T. S. Hall, Loc. No. 1273. Young Polypary.

Fig. 9. *D caduceus* Salter var. *spinifer* var. nov Loc Nò 1231. Polypary.

Fig. 10. *D. ovatus* T S. Hall, Loc No. 1231. Polypary

Fig. 11. *Tetragraptus insuetus* sp. nov., Loc. No 1231.
a Imperfect branches
b. and c. Showing aspects due to compression from different angles.

Fig. 12 *Tetragraptus tabidus* sp. nov., Loc. No 1231. Polypary.

Fig. 13. *Dichograptus octobrachiatus* J. Hall, Loc. No. 1273. Imperfectly preserved polypary.

Fig. 14. *Azygograptus prolixus* sp. nov., Loc. No 1231. Polypary.

(All figures twice natural size)

Fig 15 *Diplograptus spiculatus* sp nov Loc No 1231
- a Middle portion of polypary
- b Distal portion of polypary showing virgula Paratype
- c Distal portion showing preservation in which thecal tubes are isolated
- d Proximal and middle portions of sicula showing typical aspect Holotype
- e Proximal portion of polypary
- f Proximal portion of subscalariform polypary showing different appearance of thecae
- g Proximal thecae showing apertures
- h Incomplete polypary showing length attained

Fig 16 *D euglyphus* Lapw var *sepositus* Keble and Harris Loc No 1231
- a Incomplete polypary
- b Typical proximal portion of polypary
- c Distal thecae
- d Proximal end of polypary narrower form proximally
- e Distal end of polypary and virgula, sub scalariform aspect
- f Portion of polypary

Fig 17 *D euglyphus* Lapw var *cotius* var nov, Loc No 1231
Polypary

Fig 18 *D semotus* sp nov, Loc No 1227
Polypary

Fig 19 *D* cf *perexcavatus* Lapw, Loc No. 1231
Polypary

Fig 20 *Climacograptus* cf *antiquus* Lapw, Loc No 1231
Polypary

Fig 21 *C missilis* Keble and Harris, Loc. No 1231
- a Polypary
- b Polypary.

Fig 22 *C* cf *missilis*
Polypary distorted

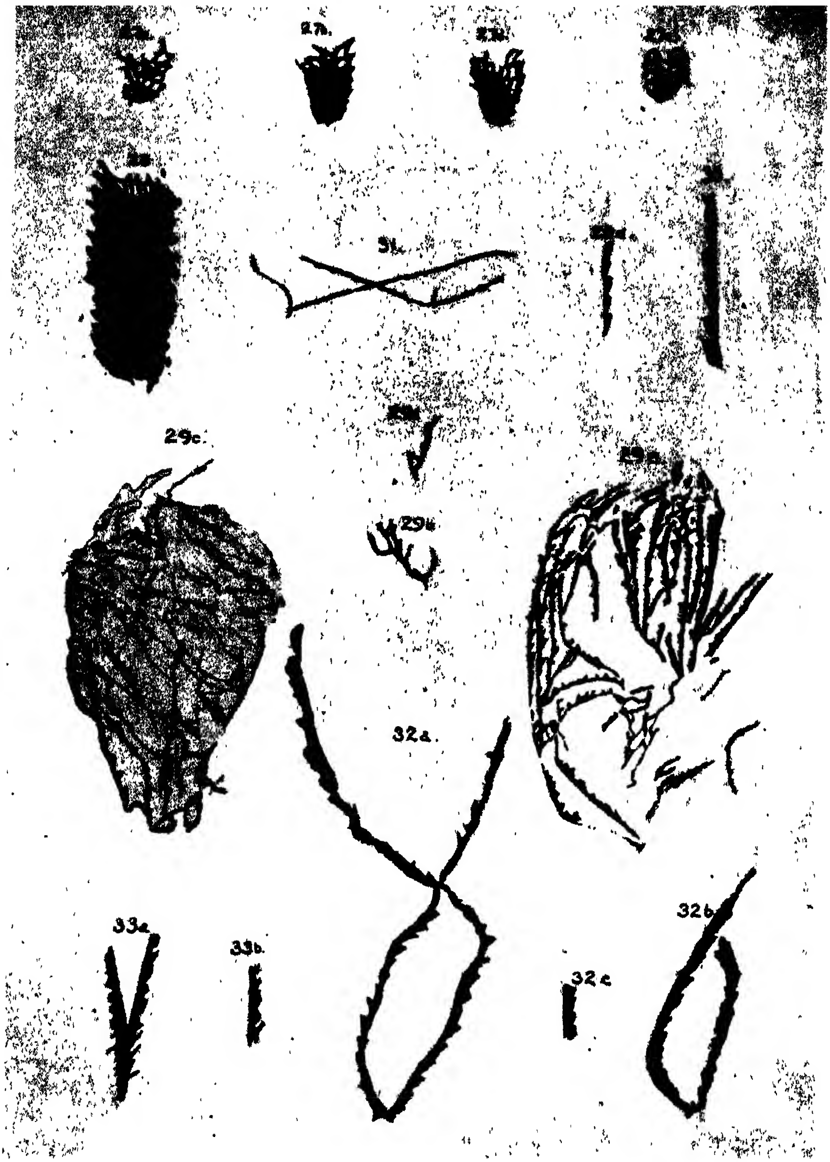
(All figures twice natural size)

Fig 23 *Cryptograptus tricornis* Carr, Loc No 1231
- a Typical polypary
- b Distal thecae
- c Club shaped compression of polypary
- d Club shaped compression of polypary
- e Proximal portion showing basal spines

Fig 24 *Glossograptus hincksii* Hopk, Loc No 1231
- a Polypary
- b Polypary
- c Small polypary
- d Distal portion of polypary
- e Proximal portion of polypary
- f Small polypary
- g Polypary
- h Small polypary

Fig 25 *G acanthus* Elles and Wood, Loc. No 1231
Polypary

Fig 26 *G villosus* sp nov, Loc No 1231.
- a Young polypary
- b Young polypary, somewhat larger
- c Complete polypary



(All figures twice natural size).

Fig. 27. *Retiolograptus speciosus* Harris, Loc. No. 1231.
a. Polypary, somewhat broken but showing inclination to parietal lists.
b Polypary, with proximal half showing attentuated test and lists in distal portion
c. Distorted polypary.
d. Polypary, with proximal half showing test but ventral lists showing in distal portion.

Fig. 28. *R. latus* sp. nov., Loc. No. 1231.
Polypary.

Fig. 29. *Syndyograptus artus* sp. nov., Loc. No. 1231.
a. Sicula and proximal thecae.
b. Sicula and proximal thecae.
c. Broken polypary.
d. Typical thecae.
e. Large broken polypary showing characteristic symmetry.

Fig. 30. *S.* cf. *pecten* Ruedemann, Loc. No. 1231.
Portion of a branch.

Fig. 31. *Leptograptus flaccidus* J. Hall var. *angustus* Keble and Harris, Loc. No. 1231.
Polypary.

Fig. 32. *Dicellograptus* cf. *divaricatus* J. Hall, Loc. No. 1227.
a. Distorted polypary.
b. Distorted polypary.
c. Thecae.

Fig. 33. *Dicranograptus* cf. *rectus* Hopk., Loc. No. 1230.
a. Polypary.
b. Thecae.

tively lax form will be difficult to procure. *T. insuetus* adds to the number of forms in New Zealand and Australia in which the Monograptus elaboration is foreshadowed; it is instructive to compare in this regard such forms as *Retrograptus circinus* Keble and Harris,* a biserial form with retroverted thecae and isolated apertures, and *Atopograptus*,† one of the Dichograptidae with similar thecae.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Tetragraptus tabidus n. sp. (Fig. 12).

Polypary attenuate, consisting of (a) two branches of first order (funicle) arising from a minute sicula at a low irregular angle, each branch consisting of two thecae less than 0.1 mm. in minimum width and 0.2 mm. in maximum width, the second pair of which give rise to (b) four branches of the second order usually curved or flexuous and attaining a width of 0.5 mm. about Th 6.

Thecae, 10 to 16 in 10 mm., proximal ones with inapproachable overlap which increases to two-thirds distally, about three times as long as wide, apertural margins straight or slightly concave, abnormal to axis of theca, outer margins straight or slightly concave at an angle of 40° to axis of branch.

T. tabidus suggests the gerontic phase of the genus *Tetragraptus*; its laxity and attenuation both point to this. The other Tetragraptid associate *T. insuetus,* if it is correctly placed generically, is not typical and appears to have sought survival by thecal elaboration; in these Cobb River beds, and in the beds immediately above and below them taking the Australasian region as a whole, thecal elaboration appears to be supplanting dichotomy. We have hereabouts the balance in favour of biserial and uniserial forms to the exclusion of the Dichograptidae. The few Dichograptidae remaining have either specialized thecae as in *Tetragraptus insuetus, Didymograptus nodosus, Atopograptus woodwardi,* etc., or suggest old age as in *T. tabidus.*

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Genus—AZYGOGRAPTUS.

Azygograptus prolixus n. sp. (Fig. 14).

Branch nearly 3 cm. long, curved, slender (–0.2 mm.) at origin, of fairly uniform breadth to Th 5, and then rapidly increasing to a maximum width of slightly under 1.3 mm., originating from a small inconspicuous sicula apparently in centre. In proximal portion of branch thecae long and narrow, four or five times as long as wide, outer walls straight up to Th 5, in contact for small portion of length, in distal portion 9 or 10 in 10 mm., inclined at angle of from 30° to 35°, twice as long as wide, outer walls slightly concave, in contact for one-half to two-thirds of their length, apertural margins normal to axis of theca.

A. prolixus differs from *A. lapworthi*—the nearest form to it in its greater maximum width, its relatively inconspicuous sicula, and the closer set of the thecae. The thecae are typical of the Dichograptidae.

Horizon—Lower Aorere Series, Zone—Dougles, Subzone—Cobb.

*Keble, R. A. and Harris, W. J., *Rec. Geol. Surv. Vict.*, vol 5, pt. 1, (*In litt*).
†Harris, W. J., *Proc. Roy. Soc. Vict.*, vol. 38 (N.S.), pp. 59-60, Pl. 2, Fig. 12-15.

Family—DIPLOGRAPTIDAE.

Genus—Diplograptus.

Diplograptus spiculatus n. sp. (Figs. 15a-h).

Polypary 10 cm. or more in length, widening gradually from a width of 1.1 mm. near sicula to a width of 2.5 to 2.8 mm., then slightly decreasing to distal extermity. Sicula minute, about 0.2 mm. long with an extremely fine inconspicuous virgella. Virgula 15 mm. or more in length, visible in polypary, moderately stout but tapering to a fine thread. Thecae alternate, long (3.5 mm.) tubes with slight double curvature, about 1.1 mm. wide near apertures, 6 to 8 in 10 mm. in proximal portion of polypary, 4 to 5 in distal portion, inclined at an angle of about 20°, in contact for about one half their length in proximal portion, and from one half to two-thirds in distal portion, aperture opening proximally into a shallow excavation which becomes obliquely elliptical distally and occupies about one-fourth the width of polypary. Aperture normal to axis of theca in proximal portion, introverted in distal region.

Sicula minute and seldom visible. First theca appears to originate near middle of sicula and grows obliquely downward towards aperture before turning outwards and obliquely upwards; it, too, is small. There is considerable variation in width, that given in the description being the mean of a number of measurements of average specimens; some over 3.0 mm. wide are known. The mature polypary must be of considerable length as fragments up to 10 cm. with both proximal and distal extremities missing are not uncommon. In the obverse aspect the proximal excavations are shallow but the distal excavations gradually become more oblique and incised and ultimately almost disappear (Figs. 15b, 15h); in the reverse aspect the apertural regions of the thecae become isolated (Fig. 15e) in the distal portion, suggesting a polypary of concavo-convex cross-section. In the subscalariform view the excavations are merely represented by the overhanging free margins of the theca above.

Of the Diplograptidae in the Australasian region *D. spiculatus* perhaps most resembles *D. coelatus* particularly in the scalariform aspect. It differs however in the more remote set of thecae, less width, absence of the characteristic sheathed virgella of *D. coelatus* and growth of first thecae, and in dimensions and form of interthecal excavations.

D. spiculatus is a striking and characteristic species and should be of zonal value. Since its first recognition in the New Zealand fauna, it has been observed in the Dark River beds in Victoria.

Horizons—Lower Aorere and Mount Arthur Series, Zones—Douglas and Lodestone, Subzones—Cobb to Mt. Peel (incl.).

Diplograptus (Glyptograptus) euglyphus, Lapw. var. **sepositus** Keble & Harris. (Figs. 16d-f.).

Keble & Harris's* description is as follows:—"Polypary 21 mm. or more in length widening from about 0.7 mm. near the sicula to a

*Keble, R. A. and Harris, W. J., New and Little Known Graptolites from the Lower Ordovician of Victoria. *Rec. Geol. Surv. Vict.*, vol. 5, pt. 1.

maximum width of from 1.5 to 1.8 mm. in 6 mm. and then of uniform width to distal extremity. Sicula small with a fine short virgella and usually curved apertural spine. Thecae alternate from 8 to 10 in 10 mm., similar to those of *D. euglyphus.*"

The New Zealand form reaches its maximum width in 20 mm., but in all other particulars agrees well with the Victorian form. Sicula about 0.5 mm. long and relatively broad. Th. 1^1 apparently originates near apex of sicula and grows downwards, outwards and obliquely upwards. Ruedemann's* description of the thecae of *D. euglyphus* is as follows:—"Thecae numbering 7 to 9 in 10 mm., overlapping less than one-third of length, inclined at an angle of about 40°; proximal part of outer wall excavated, distal part of outer edge very convex, aperture vertical to axis of theca, apertural margin concave. Intertheeal excavation deep (nearly two-fifths of width) and as long as free part of theca."

Horizons—Lower Aorere and Mount Arthur Series, Zones—Douglas and Lodestone, Subzones—Cobb to Mt. Peel (incl.).

Diplograptus euglyphus var. **coitus** n. var. (Fig. 17).

This is a variety of *D. euglyphus* that differs from the parent form in the closer set of the thecae. It has 14 thecae in 10 mm. in the proximal portion and 12 in 10 mm. in the distal portion of the polypary. In other respects it agrees well with *D. euglyphus.* As the wider set of the thecae is consistent in *D. euglyphus* and its variety *distans,* we have ventured to make a varietal distinction on this difference.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Diplograptus semotus n. sp. (Fig. 18).

Polypary widening consistently from relatively broad proximal extremity where the minimum width is 1.5 mm. to maximum width of about 4.3 mm., 13 mm. from sicula. Thecae number 9 or 10 in 10 mm. and are rapidly expanding tubes, twice as long as wide, overlapping two-thirds of their length. Outer margins usually show double curvature; apertural margins concave and normal to axis of theca. Length of type-specimen is 27 mm.

Sicula and place of origin of first theca obscure.

D. semotus outwardly resembles *D. calcaratus* var. *priscus* but differences become apparent immediately one enters into a detailed comparison.

Associates—*D. spiculatus, D. euglyphus* var. *distans, Dicellograptus* cf. *gurleyi, D.* cf. *elegans, D.* cf. *moffatensis, Glossograptus* sp.

Horizon—Mount Arthur Series, Zone—Lodestone, Subzone—Mt. Peel.

* Ruedemann, R. Graptolites of New York, *N.Y. State Museum, Mem.* 11, pt. 2, p. 369-70, Fig. 315-6, Pl. 25, Fig. 21-23.

Diplograptus cf. **perexcavatus** Lapw. (Fig. 19).

Elles, Gertrude L., and Wood, Ethel M. R., British Graptolites pt. 6, *Palaeon Soc.*, vol. 61, p. 267-9, plate 31, figs. 15 a-d.

The polypary of this New Zealand form is 9 mm. or more in length and widens from about 1.1 mm. in sicula region to 2.7 at distal extremity. Virgella absent. Thecae 15 or 16 in 10 mm., basal thecae furnished with spines, all with pronounced sigmoid curvature and wide and deep excavations occupying one-half to one-third width of polypary and more than half ventral margin.

The British specimens of *D. perexcavatus* generally appear to be somewhat wider in proximal region and sigmoid curvature of thecae less pronounced than in the New Zealand form. There is only one specimen in the collection.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Genus Climacograptus.

Climacograptus cf. **antiquus** Lapw. (Fig. 20).

Elles, Gertrude L., and Wood, Ethel M. R., British Graptolites pt. 5, *Palaeon. Soc.*, vol. 60, p. 199-200, plate 27, figs. 4 a-e.

A single specimen of *Climacograptus*, indifferently preserved, widens from a breadth of 1.2 mm. near sicula to maximum breadth of 2.5 mm. in a little over 1 cm. Excavations about one-fourth the width of polypary, and from one-fourth to one-third the ventral margin; thecae number from 7 to 10 in 10 mm. We have tentatively compared it with *C. antiquus*, but while there is a general agreement collectively between *C. antiquus* and its varietal form *lineatus*, poor preservation, particularly in proximal portion, leaves the criteria doubtful.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

This species probably ranges into the Mount Arthur Series.

Climacograptus missilis Keble & Harris. (Figs. 21a-b).

Keble, R. A. and Harris, W. J. Graptolites from Mt. Easton, *Rec. Geol. Surv. Vict.*, vol. 4, pt. 4, p. 513, Figs. 144a-d.

The original description was as follows:—

"Rhabdosome short, not exceeding 1.5 cm. in observed specimens, narrow at origin and increasing constantly in width throughout to 2.0 mm. Virgella short. Virgula visible in the body of the rhabdosome, free at the distal end for 6.0 mm. or more, and in some cases expanded into a short irregularly shaped vesicle at its apical extremity. Sicula visible for 0.6 mm. of its length. Thecae 10 to 14 in 10 mm., proximally sigmoidal, distally slightly curved, overlapping one-third to one-half; apertural margin undulate, lying within excavations which occupy one-quarter the width of the rhabdosome."

The length of the New Zealand polypary (rhabdosome) is 1.3 cm. and it increases to a width of 2.0 mm. Virgella short; virgula partly visible in polypary, free for 14 mm., but without vesicle at extremity. Thecae number 10 to 12 in 10 mm. Excavations occupy about one-quarter width of polypary. The other dimensions are somewhat uncertain.

Horizon—Lower Aorere and Mount Arthur Series, Zones—Douglas and Lodestone, Subzones—Cobb to Mt. Peel (incl.)

Genus CRYPTOGRAPTUS.

Cryptograptus tricornis Carr. (Figs. 23a-e).

Carruthers, W., *Ann. & Mag. Nat. Hist.*, 1859, vol. 3, pt. 25.

Several specimens of *Cryptograptus* occur in the Cobb River Collection and illustrate the variable appearance of this species, due to the direction of compression.

The polypary of specimen figured (No. 1231 (11) (Figs. 23c, d) is 19 mm. long and is adorned with four straight or slightly curved spines. It widens rapidly to 1.7 mm., maintains that width for about 3.0 mm., then diminishes in width until at distal end it is only 1.0 mm. wide. Fig. 23e shows the obverse aspect and basal spines. Fig. 23a is a typical aspect.

Horizon—Lower Aorere and Mount Arthur Series, Zones—Douglas Lodestone and probably Leslie, Subzones—Cobb, Mt. Peel, Flora Track and Leslie River.

Genus GLOSSOGRAPTUS.

Glossograptus hincksii Hopk. sp. (Figs. 24a-h).

Hopkinson, J. *Geol. Mag.*, vol. 9, p. 507, Pl. 12, Fig. 9.

In the Cobb River material (1231) there are specimens of this species up to 2.7 cm. in length. Breadth varies from 1.7 to 3.2 mm. From 10 to 12 thecae in 10 mm. in proximal portion of polypary and 8 to 10 in distal portion. Apertural spines strong, arcuate, and at maximum length longer than width of polypary; septal spines straight and ascending. Some specimens with consistently shorter spines (Figs. 24g, h) have some characters in common with *G. hincksii* var. *fimbriatus* Hopk. but in the Cobb River material we find some difficulty in separating them from the parent species. In one specimen (Fig. 24d) there is a suggestion of scopulae as in *Lasiograptus*.

Horizon—Lower Aorere and Mount Arthur Series, Zone—Douglas, Lodestone and probably Leslie, Subzones—Ranging up through Cobb to Flora Track and probably beyond.

Glossograptus acanthus Elles & Wood. (Fig. 25).

Elles, Gertrude L., and Wood, Ethel M. R., *Brit. Grap.*, pt. 7, p. 314, Pl. 33, Fig. 4a-c., Text Fig. 208a-b.

The polypary of the New Zealand form is 13 mm. or more in length and widens rapidly to a width of about 4 mm., diminishing distally, suggesting a sub-fusiform outline as in the British forms. Sicula obscure. Thecae 10 or 11 in 10 mm. Apertural margins apparently everted with relatively short, robust spines. Spines in proximal portion of polypary directed downwards, but towards middle become horizontal and at distal end trend upwards. Sicula extends beyond end of polypary and is provided with at least one blunt spine.

Apertural spines not as long as in British forms and there appears to be some evidence of apertural lists.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Glossograptus villosus n. sp. (Figs. 26a-c).

Sicula 1.5 mm. long, tapering. Thecae of *Cryptograptus* type, i.e., strongly everted, and showing marked curvature in apertural region, about 2.0 mm. long and 0.7 mm. broad. Basal thecae furnished with long spines, trending directly downwards, but in more distal thecae obliquely downwards. Distal thecae in contact for about one-third their length, 12 to 13 in 10 mm. Virgula gradually widening, visible throughout polypary and prolonged 4.0 mm. or more beyond. Test attenuate.

The long and tapering sicula is directed downwards as in *Cryptograptus tricornis*. Th 1^1 arises near middle of sicula growing first outwards then downwards. Points of origin of subsequent thecae are obscured by the superposition of sicula and first theca, but they are similarly curved, i.e., with a dorso-convex curvature, and are so oriented about sicula as to give polypary a sub-rounded base. The filamentous apertural margins, particularly those belonging to more distal thecae, similar to those of *Glossograptus pilosus,** in fact, the general appearance of immature polypary suggests a *Cardiograptus*†-shaped *Glossograptus pilosus*. Both *G. villosus* and *G. pilosus* develop two abnormal distal thecae in immature polyparies, but as polypary grows, it takes on more the appearance of *Glossograptus* or *Lasiograptus*. The distal V-shaped space formed by dorsal curvature of thecae in young polypary, and giving it the appearance of a reclined *Didymograptus*, is closed by inward growth and appression to virgula which projects beyond polypary as in a normal *Glossograptus*. Spines on basal thecae long but so tenuous that it is difficult to follow them for their full length. The test must have been very thin.

This remarkable species combining, as it does, the characteristics of several genera, may call for a new genus; it is only tentatively placed in *Glossograptus* because of its suggestive affinities to *G. pilosus* which, too, is abnormal in many respects.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Genus—Retiograptus.

Retiograptus speciosus Harris. (Figs. 27a-d).

Harris, W. J., *Proc. Roy. Soc. Vict.*, vol. 36 (N.S.) pt. 2, pp. 99-100, Pl. 8, Fig. 8-10.

The New Zealand specimens are usually small, less than 5.0 mm. in length and widen rapidly to 3.0 mm.; in no specimen is there a mature polypary and in every instance the polypary is broken. The test is partly preserved usually in proximal part. Medial zigzag not clearly shown. Thecae in 10 mm., 14 to 16.

Harris's remarks‡ on his species are as follows:—"This form is quite unlike any other with which we are acquainted, though, when preserved so that the two ascending zigzags coincide, the outline agrees with that sometimes shown by *R. geinitzianus*, J. Hall. Its characteristic outline, however, is quite different, and so is the

---

*Keble, R. A. and Harris, W. J., *Rec. Geol. Surv., Vict.*, vol. 5, pt. 1.
†Harris, W. J., *Proc. Roy. Soc., Vict.*, vol. 29, pt. 1, Pl. 1, Fig. 1-3.
‡*Supra cit.*, p. 100.

arrangement of parietal lists. These arise from the zigzag medial of each surface at the apices of the zigzags. Their direction, especially near the proximal end of the rhabdosome, is at first almost horizontal, but they gradually ascend and form part of what may be called the ventral strands. The thecae appear to have been sub-rectangular in section in the body of the rhabdosome and the same shape is maintained throughout, though the axis of each theca is curved upwards and the theca gradually narrows towards its aperture." We are unable to verify the upward curvature of the thecal axis and the sub-rectangular section, in fact in the New Zealand specimens the former appears to be straight and the latter round, but distortion has obviously modified them. The specimens show the characteristic outline of *R. speciosus* as compared with that of *R. geinitzianus* and the typical ascending parietal lists.

Horizon—Lower Aorere and probably Mount Arthur Series, Zones—Douglas and probably Lodestone, Subzones—Cobb but not as far as Mt. Peel.

Retiograptus latus n. sp. (Fig. 28).

Polypary with broadly rounded base and sub-parallel margins, 1.5 cm. in length and 5.5 mm. broad. Test almost continuous, attenuated, but usually thick enough to mask lists and clathria. Sicula long. Theca 11 or 12 in 10 mm. with convex or slightly-sigmoidal outer margins and concave apertural margins in contact for about one-third their length.

The test seems to have been thicker in this species than either *R. speciosus* or *R. geinitzianus* for all; the polyparies in the collection show it as almost continuous. Parts of the lists and clathria are sometimes seen either at proximal or distal ends but disclose no arrangement of them. Thecae seem to have been triangular in shape. Part of sicula lies outside polypary.

This form may easily be distinguished from *R. speciosus* and *R. geinitzianus* by (*inter alia*) its relative width.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Family—LEPTOGRAPTIDAE.

Genus—SYNDYOGRAPTUS.

Syndyograptus artus n. sp. (Figs. 29a-e).

Polypary consisting of branches (a) of the first order, two branches widening from 0.2 mm. near sicula to 0.7 mm. in distal portion. The first 4.0 mm. of proximal portion forms a broadly rounded base to polypary, the branches then gently curving upwards and apparently inwards towards axis of polypary, the whole of which is contained within angle of 25°, (b) of the second order, up to twenty branches of like dimensions arising from successive thecae in pairs (apparently sometimes singly) forming with their dorsal walls at points of origin acute angles with the branches of the first order. Sicula 0.7 mm. long, tapering. Thecae narrow simple tubes, in proximal portion 8 or 9 in 10 mm., about three times as long as wide, overlapping one-fourth their length, inclined at an angle of from 15° to 20°, apertural margins straight, normal to axis of branch, in

distal portion in contact for about one-third their length, apertural margins normal to axis of thecae.

Both specimens showing a complete polypary are distorted; they occur on the surface of a sheared slate. The following is a tabulation of the characters of the New Zealand, Victorian and American forms:—

	S. artus	*S. gracilis**	*S. pecten*†
Angle containing polypary	25°	65°	90°
Thecae in first order giving rise to secondary branches	succeeding thecae	every second theca	every third theca
Width of branches at origin	0.2	0.2	0.3
distally	0.7	0.5	0.5
Sicula—length	0.7	?	1.2
Thecae—Number in 10 mm.			
proximally	8-9	10-11	12
distally	?	8	10
Width to length, proximally	3 : 1	4 : 1	6 : 1
Overlap, proximally	$\frac{1}{4}$	$\frac{1}{3}$ – $\frac{2}{3}$	$\frac{1}{4}$
Angle of inclination	15°-20°	25°	?

Associates—List of species for Loc. 1231. *S. gracilis* occurs in Victoria with *Didymograptus ovatus, D. caduceus, D. nodosus, Glossograptus hincksii, Loganograptus logani* (mut.), *T.* cf. *quadribrachiatus, Diplograptus euglyphus* var. *sepositus, Lasiograptus* sp., *Cryptograptus tricornis* and others at the top of the Lower Ordovician. In America *S. pecten* occurs rarely with *Didymograptus sagitticaulis, Azygograptus walcotti, Leptograptus flaccidus* et. var., *Nemagraptus* ssp., *Dicellograptus gurleyi, D. moffatensis, Diplograptus euglyphus* (common), *Cryptograptus tricornis* (common) and other forms.

Horizon—Lower Aorere and probably Mount Arthur Series, Zones—Douglas and Lodestone, Subzones—Cobb and next subzone above.

Genus—Leptograptus.

Leptograptus flaccidus J. Hall var. **angustus** Keble & Harris. (Fig. 31).

The description* of this form is as follows:—Branches narrow, slightly flexed, 5 cm. or more in length widening gradually from 0.2 mm. near sicula to 0.6 mm. distally. Sicula slightly under 1.0 mm. in length. Thecae long tubes, 7 or 8 in 10 mm., inclined at 15°, about three times as long as wide in proximal portion and from three to four times in distal portion, overlapping one-fourth their length. Apertural margins normal to axis of thecae, introverted when compressed, ventral margins slightly concave.

*Keble, R. A. and Harris, W. J., *Rec. Geol. Surv. Vict.*, vol. 5, pt. 1 (*In litt*).

†Ruedemann, R., Graptolites of New York, *N.Y. State Mus.* Mem. 11, pt. 2, p. 267-8, Pl. 15, Fig. 5 and 6.

The branches of the New Zealand specimen are slightly narrower in proximal portion but otherwise the dimensions would seem to agree fairly well.

Horizon—Lower Aorere Series, Zone—Douglas, Subzone—Cobb.

Family—DICRANOGRAPTIDAE.

Genus—DICELLOGRAPTUS.

Dicellograptus cf. **divaricatus** J. Hall. (Fig. 32).

Hall, J. *Palaeontology of New York,* vol. 3, p. 513-4.

There is in the collection No. 12 a distorted and imperfectly preserved form of *Dicellograptus* showing the branches crossing. Both branches are twisted and the thecae in places face inwards; restoring the branches to their right positions the shape of the polypary would be divergent approximately at an angle of 235° in the proximal portion. The apical point of the sicula has been partly obscured and the short spines are visible on Th 1^1 and Th 1^2.

Thecae 8 to 10 in 10 mm., overlapping about one-third their length, free outer wall straight or slightly curved, apertural portion introverted. Apertural excavation one-half width of branch.

The few thecae that are well enough preserved for comparison suggest affinities to *D. divaricatus.*

Horizon—Mount Arthur Series, Zone—Lodestone, Subzone—Mt. Peel.

Genus—DICRANOGRAPTUS.

Dicranograptus cf. **rectus** Hopk. (Figs. 33a, b).

Hopkinson, J. *Geol. Mag.,* vol. 9, p. 508, Pl. 12. Fig. 9.

A species of *Dicranograptus* occurs at Leslie River Band comparable to *D. rectus* Hopk.

The biserial portion of polypary is 4.5 mm. long; uniserial branches are 6.5 mm. long, dorsal walls subtending an angle of 25° and ventral margins being in the same straight line as ventral margins of biserial portion.

Thecae 10 or 11 in 10 mm. with free outer walls straight and inclined at angle of 25°, apertural portion introtorted and introverted with stout spines opening into pouch-like excavations.

Biserial portion made up of 6 thecae on each side, is 0.4 mm. wide at its origin and 1.3 mm. wide at point of divergence of uniserial branches.

The width of the uniserial portion is 0.7. Hopkinson's species differs from the Leslie River form in that

(a) the biserial portion is longer
(b) the free outer walls are gently curved
(c) the apertural portion is not introtorted
(d) the spines are not conspicuous
(e) it is larger in all dimensions.

We have only one example, which is not well preserved, and hesitate at present to emphasize these differences by allotting specific or varietal distinction to the New Zealand form.

Horizon—Mount Arthur Series, Zone—Leslie, Subzone—Leslie River.

The Geology of the Takapuna-Silverdale District, Waitemata County, Auckland.

By F. J. Turner, Otago University, and J. A. Bartrum, Auckland University College.

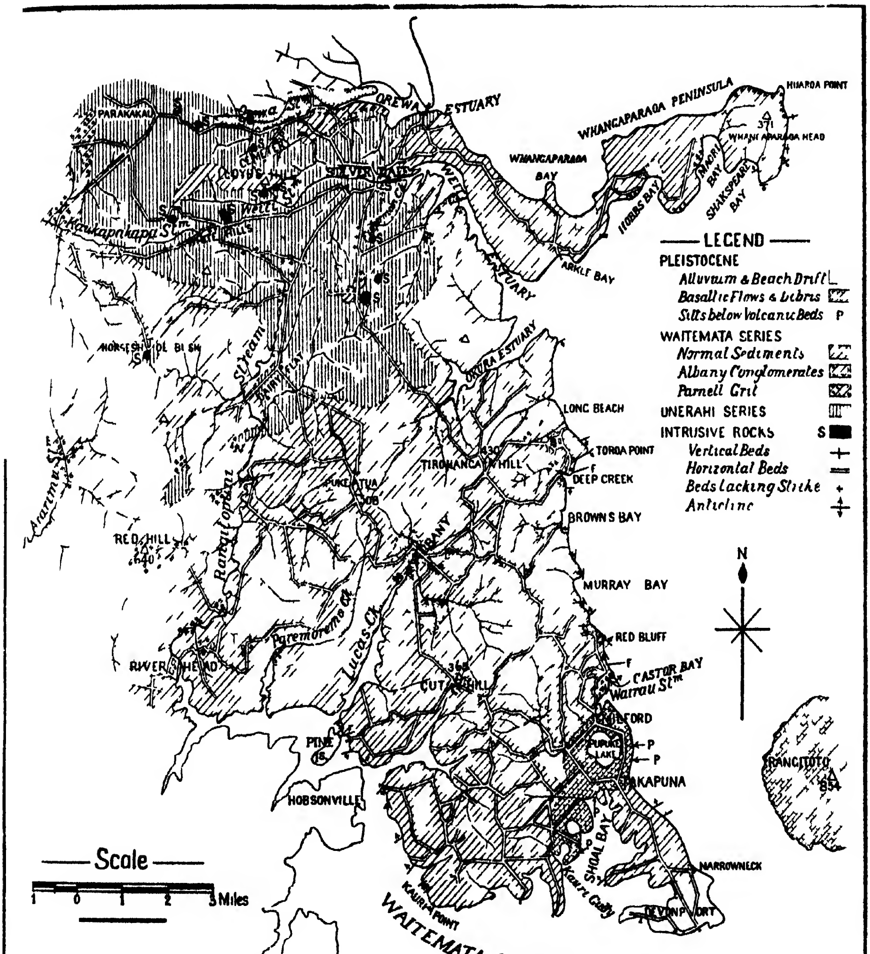
[*Read before Auckland Institute, 31st July, 1928; received by Editor, 19th November, 1928; issued separately, 25th March, 1929.*]

Plates 108–120.

Contents.

INTRODUCTION.

THE district described in this paper covers an area of about one hundred square miles between the northern shore of Waitemata Harbour and Orewa Stream, about fifteen miles north of the latter. On the east it is bounded by the western shore-line of Hauraki Gulf, and on the west joins up with the Riverhead-Kaukapakapa area



Sketch-map illustrating geology of Takapuna-Silverdale District.

described by Bartrum (1924). In order to shew the continuity of the rocks of this area with those further west, part of Bartrum's map has been added to that now published.

A small part of the district was early visited by Hochstetter (1864, pp. 13-14), but the first important work upon it was that of McKay (1884; 1884a; 1888), who made two hurried examinations of

the eastern coastal portion of the area, parts of which were also surveyed by Park (1886; 1887). In 1902, papers on the volcanic grits and breccias of the Waitemata Series were published independently by Fox and Mulgan, while more recently, facts bearing upon the geology of the district here described have appeared in two papers by Bartrum (1920; 1924) which deal with the region further west. The most northerly part of the area has recently been mapped by Mr. H. T. Ferrar of the New Zealand Geological Survey, to whom both authors are greatly indebted for generous co-operation in the field-work, and hospitality at his camp during Easter 1926. Only a brief summary of the results of his work are at present available (Ferrar, 1925a).

General Description of Area.

The greater portion of the Takapuna-Silverdale area consists of typical North Auckland "gum-land," namely an unforested upland of moderate relief, intricately dissected by insequent streams flowing sluggishly in swampy valleys between scrub-covered hills rising to between 400 ft. and 600 ft. The wide open valleys typically are graded throughout almost their whole extent, and almost invariably contain a swampy filling of alluvium resulting from soil-wash accentuated by ancient deforestation and more recent burning off of scrub. Further, there is so considerable a depth of superficial leached residual clay that outcrops of fresh rock are scarce, except along the sea-coast and, especially where remnants of forest remain, at the steeper headwaters portions of some of the streams.

The coast of the district shows, on the south and east, the long tidal estuaries and other deep embayments characteristic of a recently submerged region; these are perfectly exemplified by the drowned valley-system which now forms Waitemata Harbour, and by the estuaries of Okura, Weiti, and Orewa Streams further north. Subsequent to the submergence, wave-attack has caused the retreat of the more exposed headlands and thus developed stretches of high cliffs, which are separated by crescentic beaches in the intervening bays.

STRATIGRAPHY.

Synopsis of Stratigraphy.

Though such rocks do not occur *in situ* actually within the district mapped, there is no doubt that, as elsewhere in North Auckland Peninsula, the basement is constituted by the greywackes, argillites, and jasperoid rocks of probable Triassic or Jurassic age, to which the name Waipapa Series has been applied by Ferrar (1924) in the contiguous Rodney district, following Bell and Clarke's (1909) early usage for similar Whangaroa rocks. These are separated by a strong unconformity from a thick series of green sandstones, siliceous mudstones, and argillaceous limestones, which are grouped by the writers in the Onerahi Series of Ferrar (e.g. 1925) of probable Upper Cretaceous age, and which represent the earliest rocks actually exposed in the area described. They are invaded by serpentines and allied intrusive rocks, which apparently fail to pass upward into succeeding

strata. Above the Onerahi rocks—the writers believe unconformably —there are sandstones, mudstones, and grits of middle Tertiary age, which have long been referred to the Waitemata Series. As closing members of the sequence there are basaltic lavas and tuffs and bedded silts and gravels, all of Pleistocene age, which lie unconformably on the older rocks.

The sequence of deposition or of intrusion may be summed up as follows:—

1. Waipapa Series (Trias-Jura).
2. Onerahi Series (? Upper Cretaceous).
3. Post-Onerahi and pre-Waitemata ultrabasic and basic intrusives (? Eocene).
4. Waitemata Series (? Miocene).
5. Lavas, tuffs, silts etc. (Pleistocene).

THE WAIPAPA SERIES (TRIAS-JURA).

Though the strata of the basement series do not outcrop within the area, pebbles worn from them occur in Pleistocene and Tertiary conglomerates, and much shattered and folded greywackes of this formation are exposed in many nearby localities, as on the neighbouring islands of Tiritiri, Motu Tapu, and Waiheke. Bell and Clarke (1909) grouped similar rocks of the Whangaroa district in their Waipapa Series, to which Ferrar in more recent years (1925; 1925a) referred the greywackes of the Whangarei-Bay of Islands Subdivision as well as the rocks at present under consideration. In the absence of palaeontological evidence these Waipapa rocks have been included tentatively on lithological grounds in the Trias-Jura Hokonui System by most modern workers. (See for example Ferrar, 1925, p. 34).

THE ONERAHI SERIES (? UPPER CRETACEOUS).

General Distribution and Content.—The rocks included here in the Onerahi Series broadly form a large inlier in the northern portion of the district. On the north side of Okura Estuary they emerge from beneath the covering Waitemata sandstones and thence extend north and west, through Silverdale (Wade) and White Hills, to the northern limit of the area shown on the map. West of Silverdale they cover the country drained by the upper tributaries of Orewa, Weiti, Rangitopuni, and Kaukapakapa streams. On the western side of Rangitopuni Valley they pass beneath Waitemata rocks which continue far to the west and south, and they are similarly covered by an extensive mass of these younger beds at varying distances north of Orewa Stream.

The Onerahi beds of the area described fall into two distinct sub-series here described as the Lower Beds—concretionary green sandstones with shattered black shale and mudstone—which have limited extent, and the Upper Beds, which include much more widely-developed argillaceous limestones, siliceous claystones and mudstones —beds which may be regarded as the typical facies of the Onerahi Series.

The Lower Beds.—The rocks of the lower group were found at only four localities: a narrow strip bordering the southern foreshore of Orewa Estuary for about three-quarters of a mile west from Orewa

Heads; in the banks of Weiti Stream about one mile west of Silverdale, where the Silverdale-Kaukapakapa road crosses the stream; along the banks of Weiti Stream about five chains east of Silverdale Township; finally, a small triangular area on the eastern side of Duck Creek, where it enters Weiti Estuary, about two miles downstream from Silverdale.

The predominant rock is a micaceous glauconitic sandstone with a peculiar grey-green colour, with which are associated fine-grained black shaly mudstones, and soft green and blue clays. All are much shattered and, wherever strike and dip are observable, appear to dip at steep angles in varying directions. The glauconitic sandstone contains large calcareous septarian and other concretions, some of which are four or five feet in diameter. As already noted by Ferrar (1925a), fragments of *Inoceramus* occur in some of these concretions at Orewa Estuary, whilst indefinite broken plant-remains are often abundant. In all localities of their occurrence, the rocks of the greensand group appear to underlie the argillaceous limestones and siliceous mudstones of the upper sub-series, though whether conformably or otherwise it is impossible to say.

The Upper Beds.—In contrast with the limited outcrop of the lower beds, that of the upper or main portion of the Onerahi Series includes practically the whole of the area mapped as covered by strata of this series. Its rocks consist of a fine-grained white, grey or bluish argillaceous limestone—the North Auckland "hydraulic limestone"—with very variable content of lime, and fine-grained grey and white siliceous mudstones, or brown and purple aluminous shales which show a gradation towards the limestones in several localities. The presence of these rocks in the present area was first noted by McKay (1884a), who correlated them with his "Cretaceo-Tertiary" Mahurangi limestone. Lithologically they are exactly similar to limestones and claystones which have long been known to outcrop widely in North Auckland Peninsula, and which have been described by Ferrar (1920; 1924; 1925; 1925a) and included in his Onerahi Series. Bartrum (1924) also describes rocks of this formation in the contiguous Parakakau and Dairy Flat areas, so that little further description is necessary here.

The limestone is a very fine-grained rock, which, in the purer varieties (e.g. the rock from Okura quarry), is composed almost entirely of tests of *Globigerina* and other foraminifera, with which are a few skeletons of radiolarians and grains of glauconite or of disseminated argillaceous material (Fig. 1). Though recorded by Marshall (1917), Bartrum (1924), and others, in the hydraulic limestones of other North Auckland localities, diatoms were not distinguished in sections cut from limestones of the present area. Apart from the lowly forms mentioned, the Upper Beds are devoid of fossils. Flints are infrequent, though at Mappin's quarry, Silverdale, there is a well-marked band of flint nodules which have been intensely shattered and then re-cemented with calcite.

The siliceous facies of the Upper Beds are more widely represented than the argillaceous limestone, into which they appear to grade both laterally and vertically. The predominant rock is a very fine-grained, highly-siliceous mudstone, with its numerous joint surfaces

stained brown and black with hydrates of iron and manganese. Like the limestones, the siliceous beds are always intensely shattered, and whenever the dip is observable it appears to be at a high angle. The shattering appears to be due to pressure rather than to shrinkage of drying sediment, since even the flint nodules of Mappin's quarry, as well as the serpentines which invade the series, shew similar disruption.

Completing the facies of the Onerahi Series there are fairly thin-bedded shales apparently barren of all fossils, which constitute a type of rock which is not usually found among the beds of this formation in other North Auckland localities. They are exposed along the Silverdale-Parakakau road, two miles west of Silverdale, and again near Parakakau. In contrast with the usual conditions, the disposition of the beds is easily observable, and in all cases the dip appears to be at a steep angle in directions varying from north-west to south-west. Owing to their thin-bedded weathered state, the purple and brown shales which outcrop two miles west of Silverdale are difficult to distinguish, in the absence of palaeontological evidence, from beds of the Waitemata Series. A significant fact points, however, to their inclusion in the Onerahi Formation, namely, that at adjoining localities, such as Lloyd Hill, Waitemata sandstones rest on rocks of this series and have horizontal disposition which contrasts with the persistent inclined bedding of the latter, which can be followed at intervals for some miles across the general line of strike between Orewa and Parakakau, and preserves a steep dip in the same general westerly direction.* Substantial horizontality, or, at most, gentle inclination, is the dominant structural characteristic of the Waitemata beds; zones of acute folding are very limited in extent. On the other hand, wherever structure is decipherable, the Onerahi strata seem to be disposed at high angles.

Correlation and Age.—Ferrar (1925a) has correlated the *Inoceramus*-bearing green sandstones of the Orewa-Silverdale area with the lithologically similar beds of the Central Kaipara region grouped by him (Ferrar, 1924, p. 6) in his Otamatea Series, and by Marshall (1926) in his Batley Series, from which come abundant ammonites of Upper Cretaceous age (Marshall, *loc. cit.*). Ferrar (1925a) follows Park (1887) in postulating unconformity between his Otamatea beds and the overlying argillaceous limestones and other beds of the Onerahi Series, but the present writers find no evidence suggestive of unconformity in their district. In other areas of North Auckland, for example the Central Kaipara, the Narrows of Hokianga Harbour, the north-east portion of Mangakahia Survey District and Parengarenga, there is such very general association of ammonite or *Inoceramus*-bearing sandstones of Otamatea facies with argillaceous and siliceous limestone of Onerahi type under conditions which in no case suggest unconformable inter-relations of the two sets of beds, that the writers prefer to group both provisionally in the one series (Onerahi Series) characterized by the two facies—the lower or Otamatea and the upper or Onerahi.

*Cox (1882, p. 24) records similar relations of beds at Mahurangi which evidently belong to the two series discussed.

No fresh evidence bearing upon the controversial subject of the age of the beds grouped here as the Upper Beds of the Onerahi Series has been unearthed by the present work. Marshall (1916; 1917; 1924) has ably advocated an early Tertiary age, basing his argument largely upon the apparent superposition of the "hydraulic limestone" upon greensands at Pahi, from which definitely Tertiary mollusca have been collected. The writers' experience of the hydraulic limestones tends to indicate that structurally they are highly disturbed, and it is possible, therefore, that the Pahi section is inverted by thrusting in conjunction with folding. They hesitate to accept Marshall's view for two reasons: first, because of the close association of beds of Onerahi facies with Upper Cretaceous ammonite and *Inoceramus* beds; secondly, because of the fact that, as will appear in a later Section, they believe, with Ferrar and others, that important unconformity separates the Onerahi strata from the overlying Waitemata ones. Judged by investigations of mollusca now being made by Mr. A. W. B. Powell and one of the authors (Bartrum), these latter beds appear to correlate with either the Awamoan or the Hutchinsonian of the Oamaruian sequence. Thus, following Benson (1921) and Bartrum (1924), Ferrar's allocation of the beds here classed as the Upper Beds of the Onerahi Series to the Upper Cretaceous is provisionally accepted in this paper, though it is admitted that some of them may range upwards into the early Tertiary. As already stated, they are here believed conformably to overlie the Upper Cretaceous Lower Beds, or green sandstones of Otamatea facies.

Intrusive Rocks associated with Onerahi Sediments.

Distribution and General Petrography.—Numerous scattered outcrops of small intrusions of serpentines and other intrusive rocks of basic or ultrabasic character were located in the northern part of the area occupied by rocks of the Onerahi Formation, whilst others probably await discovery in the dense scrub and fern.

Serpentine is the commonest type of intrusive rock and outcrops of it occur at the following localities:—

1. At Matthew's quarry alongside the East Coast Road, three miles south of Silverdale. A fairly extensive mass is enclosed in siliceous claystones. Impure argillaceous limestones outcrop on the road a few chains west.

2. Two unobtrusive outcrops, probably of the same mass as that at the quarry, occur a quarter of a mile north of the latter in Matthew's Gully, a headwaters tributary of Duck Creek.

3. About ten chains east of the East Coast Road, one and a-half miles south of Silverdale, two good exposures of serpentine occur at the head of Fisherman Creek in the vicinity of outcropping limestone and mudstone of the Onerahi Series.

4. Floaters of serpentine are present on the divide between Weiti Estuary and the outlet of Orewa Estuary.

5. On the southern scrub-covered face of the Orewa-Weiti divide, about fifteen chains east of Lloyd Hill trigonometric station, serpentine is exposed in a deep shaft which was sunk by the early settlers in quest of gold, as well as at the surface close by. The serpentine

must originally have been covered by Waitemata sandstone which has since been removed by erosion, for this latter rock is visible in a horizontal drive about 30 ft. below the outcrop of serpentine and about 7 chains east of it. Sandstone of this series is also exposed in a pit sunk as a coal-prospect on the northern side of the divide about half a mile north-west of the last outcrop, and forms a continuous cap upon the Onerahi strata along the crest of Lloyd Hill.

6. A quarter of a mile south of the last exposure, serpentine again outcrops, well hidden in scrub, on the almost flat top of the spur which leads down from Lloyd Hill to Mr. Davidson's farm. Here a short deep trench was excavated in the serpentine many years ago.

In addition to the above outcrops, there are others already described by Bartrum (1924) quite close to the last two mentioned, namely in the vicinity of White Hills School and Major Jolly's farm, and in the neighbourhood of Wainui Cemetery and of Mr. David Jack's property on the Orewa side of the Lloyd Hill divide. In every case the enclosing strata appear to be those of the Onerahi Series, and the serpentines themselves are generally much shattered and slickensided.

Basic igneous rocks, which appear to represent the same period of activity as that during which the serpentines were intruded, are also known from the northern part of the district. They are seldom found *in situ*, but usually the masses are of such a size that the parent mass cannot be far distant. They include epidiorite, dolerites, and allied amygdaloidal volcanic rocks. Epidiorite has already been described (Bartrum, 1924) from near the unformed road on the east side of Wainui Cemetery, where it occurs as loose boulders. Masses of similar rock outcrop with other basic rocks near Orewa Heads; boulders of them strew the foreshore for a few chains east of the bridge. Dolerites have also been noted (Bartrum, 1920a; 1924) from the swinging basin near Silverdale Wharf, and from the bed of the Upper Orewa Stream, not far west of Wainui Cemetery, whilst they are also plentiful amongst the boulders on the foreshore at Orewa Heads. In association with them at this latter place, there are masses of altered amygdaloidal volcanic rocks which probably represent effusive equivalents of the doleritic rocks.

As a special phase of the occurrence of these doleritic rocks may be mentioned fragments found with larger ones of greywacke and of a schistose metamorphic rock, as xenoliths in the serpentine at the head of Fisherman Creek. This suggests that some at least of the doleritic intrusions were earlier than the serpentines. The schistose inclusions represent fragments of a coarse-grained strongly-metamorphic rock with large idioblasts of strongly-pleochroic brown hornblende. (See Section on Petrography). They have probably been derived from metamorphic rocks underlying the basement Trias-Jura Hokonui strata, for similar schistose xenoliths are abundant in intrusive andesitic rocks at Whangarei Heads, and are believed by Bartrum (1921, p. 121) to represent now-deeply-buried earlier Palaeozoic terrain.

Origin and Age of the Intrusive Rocks.—In his first report on the serpentines, McKay (1884) gives his opinion that the outcrops examined by him belong to three slightly converging dykes with

approximate north and south trend. Park (1887) illustrates conditions at Matthew's quarry by a section, and states that the serpentine occurs in the shaly clays which immediately underlie the "hydraulic limestone." He considers that the ultrabasic intrusives are associated with "Carboniferous or Devonian" greywackes (now referred to the Trias-Jura Waipapa Series), and evidently has mistaken some of the weathered shattered serpentine which is exposed in the vicinity of "Bond's farm" (now Major Jolly's property) for these latter rocks.

In 1888, McKay arrived at the conclusion that the serpentines constituted a definite horizon beneath the hydraulic limestone, and published the theory that they were ophicalcites derived by metamorphism of the greensand strata which lie beneath the limestone.

The writers have observed, however, that the serpentines frequently invade the Upper Beds of the Onerahi Series, and thus cannot constitute a definite horizon towards the base of this latter, whilst microscopic characters indicate that they are normal alteration products of dunites, harzburgites and other peridotites. The evidence of their intrusive character is thus complete. McKay's earlier suggestion that the serpentines constitute three long north and south dykes proves unacceptable, for the intrusions are arranged in quite haphazard fashion.

So far as date of injection is concerned, there are three possibilities: it may be pre-Onerahi, or post-Onerahi and pre-Waitemata, or post-Waitemata. Thus Park (1887) suggested, as already noted, that the serpentines were injected in pre-Onerahi times into sediments now grouped in the Waipapa Series, but their vertical distribution through a considerable thickness of the Onerahi beds, in conjunction with the lack of outcrop in their vicinity of the Waipapa rocks, is against this hypothesis, for it necessitates the assumption that during the Waipapa-Onerahi interval erosion removed the resistant Waipapa greywackes and left the serpentine projecting as residual ridges. This is highly improbable, for the serpentine is so poorly resistant that its outcrops generally have inconspicuous relief even in contrast with the soft Onerahi rocks.

The third possibility, namely that the period of intrusion was subsequent to Waitemata sedimentation, is negatived by the field-evidence, for though exposures of serpentine are very numerous amid Onerahi beds, they have not yet been found invading the Waitemata strata which enclose the Onerahi beds on every side. It is true that at Lloyd Hill, as noted, sandstone of the Waitemata Series outcrops at a lower level than adjacent serpentine, yet the maximum uprise of the serpentine above the base of the sandstone probably does not exceed 30 ft., and can very readily be explained as due to the irregularity of the erosion-surface carved from Onerahi beds and associated intrusive bodies, prior to the initiation of Waitemata sedimentation.

Benson (1926) has ably shewn that the intrusion of serpentines generally accompanies moderately intense orogenic diastrophism. As has already been shewn, there is evidence that the little-deformed Waitemata beds rest upon the steeply-inclined edges of the Onerahi ones. These conditions suggest unconformity between the two series for which other evidence is not lacking, and the writers therefore

believe that the peridotites and the doleritic and other intrusive basic rocks invaded the Onerahi strata as an accompaniment of an orogeny which occurred at the interval between Onerahi and Waitemata times, and folded the newly deposited strata. Subsequent erosion uncovered some of the intrusive masses before the Tertiary beds were laid down, not only in the present area but elsewhere, for pebbles of silicified dunite-serpentine have been discovered in conglomerates apparently of Tertiary age at Mangawhio Point, Whangarei Harbour (See Bartrum, 1925). The epidiorites, dolerites, and other basic rocks which have been mentioned earlier in this Section are the usual cognate associates of ultrabasic intrusions.

THE WAITEMATA SERIES (? MID-TERTIARY).

Distribution and Petrography.

Normal Sediments.—Beds of sandstone and mudstone which have long been grouped as the Waitemata Series, marginally overlie the Onerahi rocks on all sides, and extend many miles north, west, and south of the area here considered. Small outliers of Waitemata strata also cap the Onerahi limestones and mudstones at Lloyd Hill and again in the vicinity of Matthew's farm, about three miles south of Silverdale, and are evidently the remnant of a continuous sheet of such beds now largely removed by erosion.

The total thickness of Waitemata beds is difficult to estimate, but in the hilly country further north, between Cape Rodney and Kaipara Harbour, horizontal strata of this series appear to reach a thickness of at least 1200 ft.

The typical rocks of the series are brown and yellow feldspathic sandstones with which are interbedded thinner layers of fine gray mudstone. A not infrequent bed is composed of concretions a few inches in diameter, and is similar to a bed further north which was called by Cox (1882, p. 22) "the cannon-ball sandstone." This is generally about 2 ft. in depth and is especially well exposed on the sea-coast north of Castor Oil Bay, at the northern end of Long Beach, and between Hobbs and Maori Bays on Whangaparaoa Peninsula. The concretions generally contain a central pebble of fine-grained sometimes calcareous shale, and microscopic examination shows that the surrounding accreted matter has a calcareous cement enclosing angular grains of sand, which are exactly similar to those making up the bulk of the associated sandstone. It appears that precipitation of cementing calcite has been inaugurated and aided by the central pebble.

At times the sandstones pass into grits, and in some localities, as for example near Okura South Head and on the southern shores of Whangaparaoa Peninsula, into thin irregular lenses of interformational conglomerate. These latter contain pebbles of earlier-deposited sandstone of the same series, derived by contemporaneous erosion, along with others of a white marl which shews tests of *Globigerina* in thin section, and appears to have been derived from rocks of the Onerahi Formation.

The beds of bluish-grey mudstone intercalated in the general sandstone range from about 6 ins. to 1 ft. in thickness and shew the usual minute curved shrinkage cracks on exposed surfaces. They

frequently contain abundant fragments of carbonized wood, whilst small concretions of pyrite are often common.

The "Albany Conglomerates."—Two bands of marine beach-conglomerate containing material foreign to the district are exposed interbedded with the normal finer-grained Waitemata sediments in the bed of Lucas Creek, not far below Albany. Similar conglomerates are extensively developed north-west of the present area and attain a maximum thickness of not less than 700 ft. They have been described by Bartrum (1920; 1924) in some detail, so that brief description of their nature will suffice here.

All the pebbles and boulders of these beds, which may be called the Albany conglomerates, are well-rounded and smooth, and though generally not more than 1 ft. in diameter, are sometimes as large as 8 ft. The rock facies include varied sediments—many with probable prototypes in the Onerahi Series—and greatly-varied igneous rocks. Though andesites are the dominant types of some localities, and are usually the largest masses, the most distinctive and abundant rock throughout the whole formation is a granulated diorite which often grades into a dioritic gneiss. An isolated round boulder of norite discovered by Bartrum (1920a) in Waitemata sandstones at the mouth of Wairau Stream, Milford, probably represents material similar to that of the conglomerates further north, which was entangled in drift-wood and so carried well away from the shore.

Bartrum (1920) noted the occurrence of a band of much-weathered conglomerate in a deep road-cutting at Cut Hill, three miles south of Albany on the road to Birkenhead. Recent excavations have exposed somewhat less-weathered material, and shew that the conglomerate dips south-east at about 70°. At the north end of the cutting there is a mass of inclined cross-bedded fine-grained sands and mudstones, which continue south for about 20 yds., and then give place to a bed 6 ft. thick of coarse-grained conglomerate which contains rounded boulders, up to 2 ft. in diameter, of siliceous material probably derived from the Onerahi Series. Finally a finer-grained conglomerate, with pebbles averaging about 2 ins. in diameter, comes in above this bed and extends for 20 yds. to the south end of the cutting. Most of its pebbles or boulders are of weathered sandstone apparently worn from earlier Waitemata beds during a phase of contemporaneous erosion. There are also a few pebbles of siliceous material similar to those of the lower band just described, whilst larger masses, as much as 1 ft. in diameter, of a greatly-weathered igneous rock resembling andesite are scattered throughout this and other beds of the conglomerate at this locality. The diorites characteristic of the Albany conglomerates are entirely absent.

In discussing the origin of the Albany conglomerates it is necessary to draw attention to the fact that beds similarly containing pebbles of plutonic rocks which are often affected by pressure have been described from Mesozoic and Tertiary strata in a number of localities in the North Island, as, for example, the central portion or King Country (Park, 1893), near Kawhia (McKay, 1884c, p. 145), on the East Coast near Gisborne (McKay, 1887; 1884b, p. 72), Great Barrier Island (Bartrum, 1921) and at Mangapai and Onerahi on the Whangarei Harbour (Bartrum, 1921a; 1924a).

Occasional dioritic boulders also occur at Kaipara Harbour (Marshall, 1917), in the North Cape area (Bartrum and Turner, 1928) and, as determined by a recent visit of the authors, near the mouth of Waimamauku Stream south of Hokianga Harbour and at Hokianga South Head, in conglomerates which are dominantly andesitic in character and have been unhesitatingly correlated with the Waitakerei fragmental volcanic beds. These latter are generally accepted as constituting a horizon above the sedimentary facies of the Waitemata beds near Auckland. This fact of the distribution of the diorites raises the interesting question whether the North Cape conglomerates in particular, in view of their somewhat plentiful dioritic pebbles and intercalation in fossiliferous normal Tertiary sediments, should not be regarded rather as the equivalent of the Albany conglomerates than of the Waitakerei "breccias." Such a correlation is further supported by the stratigraphic position of the Hokianga conglomerates, which appear to lie at no great distance above the basement of Onerahi limestones.

The origin of the pressure-affected plutonic and other pebbles is of particular interest in view of the fact that no plutonic rocks have been discovered *in situ* within very considerable distances of outcrops of Albany conglomerate. Bartrum (1920) has discussed the facts fully, and there is no need to add to his statements regarding the known occurrence of coarse-grained batholithic or other intrusive masses, beyond the fact that the present authors have recently found that the gabbroid masses described in association with peridotites by Bell and Clarke (1910) have local gneissic facies, and that small batholithic masses of basic intermediate or basic composition are not infrequent over a wide area both north and south of Hokianga Harbour.

Conclusions summarized elsewhere may well be quoted "The granulated and sheared plutonic rocks are believed to be representatives of a buried terrain which was in existence before and during the deposition of Trias-Jura sediments exposed in neighbouring areas, which are the oldest rocks so far discovered *in situ* in the North Island of New Zealand. This terrain apparently persisted into Tertiary times, for the Miocene conglomerates appear not to be a rewash of mid-Mesozoic ones." (Bartrum, 1924b).

"Parnell Grit" Horizon of the Waitemata Series.

General Description.—A further variation from the normal sandstones and mudstones of the Waitemata Series is shewn in bands of fine-grained volcanic grits, tuffs, and in some places coarse-grained breccias and agglomerates, which outcrop freely along the east coast north of Takapuna, and have been described by earlier writers as the "Parnell Grit" or "Cheltenham Breccia." Detailed descriptions of the material of the beds have been given by Fox (1902) and Mulgan (1902) to supplement the more general statements of Hochstetter (1864), Cox (1882), Hector (1886), and Park (1889). Outcrops of material distinctive of this horizon were noted within the present area at the following places along the eastern coast:—

1. Castor Oil Bay, Milford. At the south head of the bay there is typical coarse material. At the north head fine tuffaceous material probably represents the same horizon.

2. Red Bluff.
3. On both sides of the bay at Deep Creek.
4. Beside the road to Tirohanga Hill, one mile inland from Long Beach.
5. On the western side of Hobbs Bay, Whangaparaoa Peninsula.
6. On the western side of Maori Bay, Whangaparaoa.
7. Along the north coast of Whangaparaoa Head.

Fox (1902) also mentions an outcrop on the north side of Okura Estuary, whilst other outcrops may exist west of Manly on the northern shore of Whangaparaoa Peninsula, for this area was not examined. Similar beds have been recorded by McKay (1884a, p. 104) and others from as far north as Puhoi.

For so wide-spread a bed the " grit " is fairly uniform in material, though subject to variation in texture. It typically consists of angular fragments, about one-quarter to one-half inch in diameter, of andesite and Waitemata sandstone set in numerous interstitial particles of the same materials partially cemented by calcite. Larger masses of sandstone and andesite from 3 ins. to 3 ft. in diameter are often scattered sparsely through the rock, especially where it is a little coarser in texture than usual. In several places, as on the southern side of Castor Oil Bay, there are enclosed blocks of carbonaceous mudstone which are possibly derived from subjacent Onerahi beds.

By far the greater proportion of the volcanic material is comprised of porphyritic and often vesicular andesitic rocks, though more acidic trachytic ones have been recorded (Bartrum, 1917). Isolated crystals of augite and plagioclase are sometimes numerous. Abundant varied Bryozoa occur in almost every locality where the grit is developed, though unfortunately they are unfavourable for exact determination, since perfect specimens are hard to obtain.* Other fossils of Parnell Grit horizon include Foraminifera and the broken remains of lamellibranchs, corals, echinoderms and crustaceans.

Cross-bedding is a prevalent feature in most of the bands of " grit," and lenticular beds shew transition both laterally and vertically from coarse to fine facies in the most abrupt fashion. Wide-spaced joints are usually well displayed, with the fissures occupied by veinlets of calcite which sometimes exhibits good rhombohedral and scalenohedral crystals. Fox (1902, p. 461) records veinlets of zeolites, but none was noticed by the present writers. The contact between the " grit " and underlying Waitemata beds is often a faulted one; where the sequence is uninterrupted, however, the volcanic beds appear conformably to overlie the normal sediments (Fig. 2). There is often interdigitation of lenses of sandstone in the basal portion of the grit, indicating a transition from one set of beds to the other, though Ferrar (1925a) considers that in some cases slight unconformity is indicated at this horizon. Hector (1886) similarly held that such unconformity exists, and removed the beds above it from the Waitemata Series.

---

*Fox (1902) lists a number of species obtained near Auckland, but his determinations have not yet been revised by competent workers upon this group.

Coarse-textured breccias which occur in the high sea-cliffs of the northern and eastern coasts of the small peninsula known as Whangaparaoa Head, which terminates Whangaparaoa Peninsula itself, constitute an important special phase of the Parnell Grit. Interbedded with acutely-disturbed sandstones, they outcrop almost continuously for about three miles, and at the most northerly point of the peninsula, about three-quarters of a mile west of Huaroa Point, take the form of a very coarse breccia or agglomerate. The included fragments here average about 3 ins. or 4 ins. in diameter, whilst many of the constituent blocks of andesite—the prevailing rock-type—are as much as 3 ft. across. An interesting and important feature is the occurrence in the breccia of large angular fragments of limestone, as much as 5 ft. in greatest dimension, which consist mainly of Bryozoa, *Amphistegina* and other Foraminifera and echinodermal remains (Fig. 5). In constitution it thus resembles closely the Whangarei limestone (see Marshall, 1916, p. 91), and that near Papakura, the former of which has been placed by Ferrar (1924; 1925) near the base of the Tertiary sequence in that area, whilst the latter has long been placed at or near the base of the Waitemata Series (see, for example, Park, 1886).

Other interesting inclusions in the breccia of Whangaparaoa Head are occasional boulders about 3 ins. in diameter which contrast strikingly in their well-polished nature with the general angular material. Petrographically they consist of greywacke and of andesites and gneissic diorites indistinguishable from those of the Albany conglomerates. In addition, a pebble sectioned proved to be a fine-textured submarine tuff (Fig. 6) containing fragments of pyroxene and of a dark aphanitic rock set in a calcareous matrix in which remains of broken pelecypod shells and tests of *Rotalia* and other Foraminifera could be distinguished.

The explanation of the incorporation of these boulders in the agglomerate, along with the masses of limestone and sandstone mentioned above, lies undoubtedly in their disruption from subjacent beds by volcanic eruptions (evidently at no great distance) which supplied the andesitic débris constituting the main mass of the deposit. The existence of limestone beneath the sandstones of the area is what might be expected in view of its outcrop near the base of the Waitemata Series on nearby islands, but it is especially interesting to have the suggestion, if not demonstration, of the extension of the Albany conglomerates far east of their surface outcrop.

Horizon and Origin of the Parnell Grit.—Much has been written by earlier workers regarding the stratigraphic position and origin of the Parnell Grit, but the evidence is by no means conclusive. Cox (1882, p. 25) points out that it overlies the foraminiferal beds at Orakei Bay, Auckland—a fact certainly supported by recent disclosures of the grit in the railway cut near Orakei Basin—but this by no means delimits its position in the whole series. He is further inclined to regard the deposit as material spread on the floor of the shallow Waitemata sea by the earliest of the eruptions which had their culmination when the rocks now consituting the agglomerates, breccias, and conglomerates of the Waitakerei Hills were hurled out to form a mass nearly 1000 ft. in thickness. Park (1886) similarly

correlates the Parnell Grit with the Waitakerei breccias and places both near the top of the Waitemata Series.

On the other hand, near Mahurangi Heads (Fox, 1902, pp. 474-475), beds which are referred to these grits lie not far above limestone belonging to the Onerahi Series, whilst the writers' observations on the Auckland-Riverhead section make it clear, in spite of complications introduced by local sharp corrugations and dislocations, that the tuffaceous beds at Parnell Point are overlain by several hundred feet of sandstone. It thus appears certain that the eruptions which spread this volcanic débris were not limited to the final stages of Waitemata sedimentation.

Fox (1902) subdivides the Parnell Grit, using the term in the comprehensive fashion adopted here, into two phases which have different sources and dates of origin, but this is unsatisfactory, since the correlation of beds only a few feet thick and often many miles apart is based only on variations in texture combined with minor lithologic changes. He suggests that his "Cheltenham Breccia," which includes most of the Parnell Grit in the present area, derived its andesitic débris from the line of vents which gave source to the Waitakerei Hills about 15 miles west of the Takapuna-Silverdale coast-line, an opinion more or less shared by Mulgan (1902) and in agreement with that of Park (*loc. cit.*) and others.

Two objections may be urged against this view. First, the Waitakerei breccias have been accepted by all workers on the geology of the Auckland district as at the top of the Waitemata beds (see Cox, 1882; Park, 1886); most writers regard them as conformably above these latter (see, for example, Marshall, 1908), though Bartrum (1924) finds evidence near Kaukapakapa suggestive of unconformity, which is strengthened by that now available from the Huia tunnel recently excavated in connection with Auckland water-supply. The tunnel follows a thin slightly lensoid bed, often only about 2 ft. in thickness, which is interbedded at the west end of the tunnel with sandstones of Waitemata facies. This bed consists of fine-textured angular volcanic débris, with occasional well-rounded pebbles of greywacke and andesite, and contains poorly preserved molluscan shells, a few Foraminifera, and other fossils. Towards the eastern mouth of the tunnel this material appears to grade into coarser débris of the Waitakerei breccia formation, the contact between the two sets of beds being indistinguishable. These facts appear to indicate that the Waitakerei breccias rest upon an uneven erosion surface of the Waitemata beds.

In the second place, the irregular variation in texture of the "grit" from place to place, the lensoid nature of the beds, their rapid change in thickness in any particular locality, and the total absence of any trace of a former large central vent, all lend support to the view that the component andesitic material was supplied from a number of small centres of eruption rather than from a single major one. Nevertheless the petrographic uniformity of the included volcanic débris points to a common magmatic source for it all, and it is therefore believed that the Parnell Grit, though not a continuous stratum, consists of a series of lenses which occur, in the main, approximately at the same horizon in the Waitemata Series, though

similar material may also be found at other levels within that series. As already suggested, it is probable that a considerable lapse of time separated the deposition of the greater portion of the Parnell Grit from that of the Waitakerei breccias.

Basalt Entangled in Waitemata Beds at Whangaparaoa.—A large horse of columnar basalt about 20 ft. in diameter has been entangled, along with large blocks of Parnell Grit, in highly dislocated Waitemata strata three-quarters of a mile west of Huaroa Point, Whangaparaoa Head. From its microscopic characters it is possibly the basalt, said to have come from Wade (Silverdale), which has been described by Sollas and McKay (1906, p. 158), and believed by them to belong to the same period of eruption as the Pleistocene or sub-Recent basalts near Auckland. The present writers prefer to regard it rather as approximately coëval with later Tertiary basaltic intrusions at Sugar Loaf, near Matakana, and Ti Point (Bartrum, 1920a) about 20 miles to 25 miles further north. The main evidence in favour of this view is the fact the altered olivine of the Whangaparaoa rock contrasts strikingly with the unaffected mineral of the Auckland basalts, but strong support is added by the knowledge that these latter were not erupted until long after all important movements connected with the orogeny by which the Waitemata beds were disordered had ceased. The Whangaparaoa basalt, on the contrary, preceded this period of stress.

Structure of the Waitemata Series.—Viewed broadly, the beds of the Waitemata Series of the present district resemble those of other areas in their simple, gently-inclined or horizontal disposition, though superposed upon this simple structure there is local complexity shewn by relatively narrow zones of acute folding and fracture. Park (1910, pp. 133-135) summarizes these facts, publishing a diagram illustrative of the complex local dislocation of the beds, and ascribes this latter to "thrust exerted by the comparatively recent volcanic outbursts." Though this certainly is suggested by the section at the west head of Tamaki Inlet, near Auckland, where a dissected basaltic cone is associated with considerably-disordered Waitemata beds, yet it is entirely negatived by the clear evidence that the Auckland basalts have everywhere buried topography carved subsequent to deformation.

It is exceedingly difficult to systematize the structural disposition of the Waitemata strata in the present area, because of the constant local complexity. Between Milford and Ohura Estuary, however, there is synclinal arrangement of the beds which was early pointed out and figured by McKay (1884, p. 103). This can also be distinguished, with superimposed minor corrugations and fractures, in the section along the shores of Waitemata Harbour from Kauri Point to Lucas Creek. The axis of the syncline appears to trend approximately north-east and south-west, for a north-east strike is very general.

Another fairly large area over which the general attitude of the beds is relatively simple is Whangaparaoa Peninsula, with the exception of its extreme eastern portion, for a slight westerly dip is very constant.

Turning, however, from these areas to those where faulting or corrugation is evident, it is almost impossible to unravel the tangled skein of facts—facts so numerous that their incorporation in this paper is impracticable. Normal faults, reverse faults with associated overturned folds, and possibly also flaws, constantly succeed one another and trend with directions so diverse that their maze almost obliterates evidence of structural control in their creation. It is indeed probable that a N.E.-S.W. disposition of such fault and fold axes is dominant, a fact which is in keeping with observations recently summarized by the present writers (1928, pp. 135-137), which shew that the structure of the Auckland area and of North Auckland Peninsula is governed by two series of great fractures arranged in rectangular pattern, of which the lesser trends north-east and south-west. It is also possible to co-ordinate the broader features of the two most extensive and intensive zones of compression traversing the present area. One of these (Figs. 7-9) is perfectly portrayed in the sea-cliffs between Wairau Creek, Milford, and Red Bluff, about two miles further north, and the other is at Whangaparaoa Head (Figs. 11-14).

The Milford section exhibits an example of thrusting which invariably proves a delight to all geological visitors. The base of the visible section shews that the beds below the lowest thrust 'sole' have been crumpled and overturned by frictional drag. Above them there are at least two thin lensoid overthrust sheets, followed by a much thicker one with a minimum thickness of at least 30 ft. (See Fig. 7). The edges of its strata are indragged in most interesting fashion at the thrust-plane (Fig. 8), and it is interrupted by two narrow zones from 15 ft. to 25 ft. in width in which sub-vertical beds are entangled (Fig. 9).

The writers had early attempted to refer these zones of sub-vertical strata to intilting along faults developed subsequent to thrusting from a south-west direction, but could not find this explanation satisfactory. Nor did the hypothesis that these zones followed the course of flaws prove more acceptable, and they are indebted to Dr. Leon Bossard for a suggestion which explains the facts more satisfactorily than the other hypotheses. This is that the sharply-tilted strata represent beds forced against a resistant foreland at the toe, somewhat arcuate in plan, of an overthrust mass advancing approximately from the south-west. This latter was compelled to develop temporarily sub-vertical reverse faults, and then to over-ride the obstructing mass at higher levels. Particular support is afforded this hypothesis by the fact that the over-ridden beds include especially rigid strata in a band of Parnell Grit approximately 15 ft. in thickness, 'horses' of which have been included in one of the zones of disturbance (Fig. 7). As will be pointed out later, there is further suggestion from elsewhere that the Parnell Grit frequently provides a resistant mass upon which the weaker normal facies of the Waitemata Series are overthrust or piled up in close folds.

Corroborative evidence is yielded also in the drag of the edges of the beds of the major overthrust sheet down the plane along which the most pronounced dislocation has occurred, which, further, appears to die out seaward, a fact which suggests that actually it

merges into a sharply arcuate, variably-inclined fracture bounding the front of an advancing sheet.

The incidence of pressure at Whangaparaoa is perhaps even more remarkable than at Milford, but its features are not so familiar on account of its comparative inaccessibility. Highly detailed mapping is necessary before the full scheme of events can be unravelled, and this was impossible in the limited time available. Nevertheless, a major rock-sheet, which has been thrust apparently from a more or less southerly direction, is clearly recognizable for a distance of about half a mile north and a similar distance south of Huaroa Point. Lenses of Parnell Grit are thrust one over another, whilst normal faults have combined with the thrusts to render the disposition of the strata such that it can only be described as chaotic (See Figs. 13, 14). Certain details of structure displayed in the almost uninterrupted sea-cliffs and broad cut-platforms are well worth brief record. On the northern side of the isthmus which separates Maori Bay from the northern coast, the beds undulate gently, but trend uniformily about E.N.E. Passing east, however, Parnell Grit soon appears, affected by intense faulting movements which have displaced lenses of the grit itself, brecciated the sandstones and indragged them along the fault zone. Moderately complex folding is exhibited for about half a mile further eastwards (See Fig. 11) and then, about three-quarters of a mile west of Huaroa Point, the pressure finds its expression in the development of overthrust sheets amongst which large masses of coarse volcanic breccia and one of the columnar basalt described in an earlier section are entangled. A quarter of a mile further east, upward shearing is perfectly displayed, and there begins also the major sub-horizontal thrust from a southerly direction which has already been noted. South of this zone of thrusting, folding again becomes the most noticeable expression of the disturbing forces, and such close folds are displayed that the beds stand vertical for distances of several chains across the strike. Beds of coherent sandstone 2 ft. or more in thickness may be bent through almost 180°, close examination alone revealing that the displacement has been adjusted along innumerable tiny fractures.

One of the most noteworthy characteristics of the intense local deformations prominent in the Waitemata beds is the fact that they are almost always best developed in association with coarse or moderately-coarse beds of the Parnell Grit. This applies to other districts near Auckland in addition to that now described. Hochstetter (1864, p. 13), with his characteristic acumen, remarks on this at Whangaparaoa, and, in explanation, as quoted by Hector (1886, p. 39), advances the theory that the grit " . . . . is an eruptive formation which has penetrated between the sandstones and clay-marl strata, torn them asunder, broken them, and by lateral pressure to the westward forced them out of their original situation."

This association of the grit with zones of complex yielding to compressive forces is too frequent to be merely a coincidence. An explanatory suggestion which may present itself is that the grit is low in the Waitemata sequence and comes to the surface only when brought there by folding or thrusting. There are good reasons for believing that this is not so, for at Whangaparaoa, as explained pre-

viously, there is evidence that beneath the grit there are the Albany conglomerates, which appear to be distributed through a considerable depth of strata (Bartrum, 1924).

A preferable explanation, which is supported very strongly by the phenomena of the overthrust at Milford, is based on the massive comparatively unyielding character of the bed or beds of Parnell Grit. Its lensoid strata have acted as obstructive masses against which more yielding beds have been piled up in folds by lateral pressure, and, when the limits of its own resistance to shearing have been exceeded, it has itself been piled up in small overthrust sheets.

On summarizing the facts, it must be emphasized that no physiographic evidence of fractures of the N.W.-S.E. series which are so important near Papakura and Brookby about 15 miles to 20 miles south-east from Takapuna, can be obtained in the present area, nor could it, perhaps, have been expected, in view of the poorly-resistant nature of the underlying strata. Nevertheless, facts have been set forth which shew that there has been moderately intense compressional force acting from a south-western direction, which has given origin to thrusts representing a special phase of the same post-Waitemata orogeny (the Kaikoura orogeny of Cotton, 1916) as is evidenced by the major faults near Papakura, sub horizontal movements having temporarily superseded vertical.

The inference drawn by the authors is in accord with their views of the structure of North Auckland Peninsula (Bartrum and Turner, 1928, pp. 135-137). They believe that their area represents a laterally compressed member of a series of elongated sub-parallel blocks rising along a N.W.-S.E. fold-axis delineated long previously in early Cretaceous times. It would appear that its structure, in a broad way, is anticlinal, with the strike of the accompanying thrusts sub-parallel to the anticlinal axis.

Special complications have arisen, however, in response to the presence of structural elements of the complementary N.E.-S.W. series. It has been shewn earlier that these are indicated in the disposition of the strata, and it can now be stated that physiography also indicates control of this kind. That this is so is suggested by such phenomena as the direction of Whangaparaoa Peninsula and the very general N.E.-S.W. trend of streams of the district and of certain cuesta-like divides which are by no means uncommon, especially both east and west of Lucas Creek.

In addition to the structural characteristics of the Waitemata beds which have been described and discussed, there are others which are not without their interest. Amongst them is the presence of interformational dislocations and folds, which are generally present on a minute scale, and are then limited to a layer not over 1 ft. in depth. One of the best examples is near the sewerage discharge about three-quarters of a mile south of Takapuna Beach, where a bed about 2 ft. 6 ins. in depth is complexly corrugated. The probable cause is subaqueous gliding of delta-beds down the slope of the delta, when growth has caused over-loading, for the local examples exactly resemble those figured by Grabau (*Principles of Stratigraphy*, 1913, p. 783, Fig. 167) from Canada.

Relation of the Onerahi and Waitemata Series.—The question as to whether or not unconformity separates the Waitemata beds from

the Onerahi rocks below them has given rise to much discussion ever since Cox (1881) first suggested that the series are unconformably related. Whilst members of the present Geological Survey (e.g. Ferrar, 1924; 1925) support the view that the Waitemata Series rests on the eroded surface of the Onerahi Formation, Marshall (1917) has expressed the contrary view that the hydraulic limestones of North Auckland (part of Ferrar's Onerahi Series) lie between the Waitemata beds and the Early Tertiary Whangarei limestone, and form part of an unbroken Tertiary sequence. In 1924 he again affirms the Tertiary age of the hydraulic limestones.

A number of indications that unconformity does exist may be observed in the area here described ,and may be enumerated briefly as follows:—

1. Pebbles lithologically similar to the more siliceous members of the Onerahi Series are found in many of the bands of conglomerate which are widely scattered through the Waitemata Series, especially in those at Cut Hill. Other pebbles, such as some from the Albany conglomerate and the Parnell Grit at Whangaparaoa, include *Globigerina*-bearing marl which resembles closely the Onerahi hydraulic limestone.*

2. The rocks of the Onerahi Series universally shew intense shattering in contrast with the unshattered massive beds of the Waitemata Series. That this shattering is the result of pressure, and not merely of shrinkage during drying of the beds, is clearly shewn by the presence of similar fractures in a band of siliceous nodules included in the limestone at Mappin's quarry, Silverdale.

3. When their stratification is discernible, the Onerahi beds always dip at steep angles, in marked contrast with the normal gently-undulating or sensibly-horizontal disposition of the Waitemata strata.

4 In some localities horizontal Waitemata beds rest on the Onerahi rocks at heights above sea-level which vary widely at points relatively close one to another. This may be explained by faulting in any specific case, but such occurrences are so frequent over a wide area, which includes not only the present district but most of North Auckland, that the best explanation is afforded by the assumption that a highly irregular erosion-surface separates the two series.

5. It has already been shewn that ultrabasic rocks invaded the Onerahi strata prior to the deposition of the Waitemata Series. Benson (1923, p. 53) remarks on this, and suggests that they are coëval with serpentines which were injected into the rocks of New Caledonia during an important Early Tertiary orogeny, for New Zealand and New Caledonia shew considerable structural similarity and lie on the same great fold-arc.

There is in addition strong presumptive evidence that long-continued erosion superseded the orogeny, for, as has been shewn, at Lloyd Hill serpentine, intrusive into the Onerahi beds, appears to have been denuded of its cover prior to the Waitemata transgression.

6. In areas south-east of Auckland, and in others north and east of the district described in this paper, the Waitemata strata rest on

*Similar evidence has been adduced from neighbouring districts by Cox (1881), Henderson (1914), Bartrum (1924, pp. 143-144), and others.

a basement of the Hokonui (Trias-Jura) greywackes, though, in numbers of other localities, often not far distant from the first, they lie on Onerahi strata. It is true that the absence of these latter beds near Auckland and south of that city may be explained by differential subsidence of the area of deposition in Onerahi times, subsidence beginning earlier in the north than in the south, but further north such an explanation cannot hold, for the changes of the basement series are too rapid. Further, in conjunction with these changes the undoubtedly great, though unknown, thickness of the Onerahi beds and their wide extent are greatly against an explanation of the facts on the basis of overlap of the Waitemata beds upon lower strata as the uppermost members of a conformable sequence, and the hypothesis of unconformity remains as the more satisfactory alternative.

After due consideration of the evidence adduced, the writers are inclined strongly to the belief that Onerahi sedimentation was terminated by uplift associated with acute stress which had as accompaniment the injection of basic and ultrabasic intrusions. Erosion intervened for a sufficient time to permit the removal of the soft Onerahi cover from areas that were relatively uplifted by folding or warping, and underlying Hokonui rocks were bared, to sink in their turn beneath the transgressing Waitemata seas.

Origin of the Waitemata Series.—The gritty nature of many of the sandstones, the frequent development of bands of beach-conglomerate, often of great thickness, the presence of thin lenses of interformational conglomerate, and the abundant fragments and even whole tree-trunks of carbonized coniferous wood which occur in many of the mudstones, render it evident that the rocks of the Waitemata Series originated as delta-deposits laid down rapidly in a shallow sea. Ripple-marks are very constant, and help to indicate the shallowness of the water. From the rarity of marine fossils it appears that the rivers brought in such floods of waste that the waters near shore were unfavourable for molluscan and other similar life. The area of deposition was relatively extensive, for in spite of long-continued denudation subsequent to uplift, the Waitemata sediments to-day are present over an area approximately twenty miles wide, which extends from forty or fifty miles north of Auckland to a considerable distance south of that city, and in some localities are as much as 1200 ft. thick.

The exact location of the Tertiary land-mass from which this sediment was unloaded is difficult to fix, but the coarse-grained nature of the sandstones and wide development of conglomerates north-west of the district here described, suggest that the bulk of the material came from that direction. In the vicinity of Wainui Hill east of Kaukapakapa, in particular, fragments in the Albany conglomerate attain truly remarkable size, many exceeding 7 ft. in diameter. The larger of them are mainly andesite, but occasional dioritic masses at least 4 ft. in average diameter can also be found, whilst smaller boulders include greywackes and other sediments as well as varied igneous rocks. This indicates clearly that a greywacke terrain, varied locally by protruding dioritic batholiths, younger sediments, and andesitic and other eruptives was close at hand, drained by rapid streams which built up deposits upon the sinking sea-bottom which include a lensoid mass of coarse gravels over 600 ft. in maximum depth.

There is very clear evidence that the material does not come from an eastern land in the nature of the basal beds of the series on its eastern margin. These include beach-conglomerates lying hard upon the Mesozoic greywackes from which they have been worn, above which are plant-bearing quartz-sandstones and fireclays with which bands of coal are associated at Hunua, Drury, and Bombay. Above this there are marine beds sometimes in the form of foraminiferal shales, but more often as sandstones. At Maraetai, the Papakura-Clevedon area and Kawau Island—this last far separated from the other more southerly localities—there are more or less impure flaggy limestones, built of broken bryozoan, algal, and echinodermal remains, with foraminifers and occasional brachiopods and molluscs, which closely follow the basal conglomerate. Shorewards they grade into calcareous sandstones and evidently represent deposits formed in relatively clear water at some distance from the growing Waitemata delta. Later, however, the advance of this latter inaugurated the ubiquitous succession of sandstones, with intervening narrow layers of mudstones, which cover the limestones.

The phase of sedimentation which has been outlined was punctuated by an outburst of volcanic activity during which, it is believed, andesitic cones rose above the seas of Waitemata times in the region now occupied by the western part of Hauraki Gulf, and gave rise to the tuffs and breccias of the Parnell Grit. These cones were soon removed by erosion, and deposition proceeded as before.

Before Pliocene times the general transgression became reversed at the initiation of the Kaikoura movement of uplift, and the sedimentation soon ceased, to be followed shortly by the emergence of wide areas of Waitemata beds along the fractured flanks of the great anticline of North Auckland. Long-continued erosion upon the compressed and fractured blocks has subsequently developed the major features of the present topography.

POST-TERTIARY DEPOSITS.

Post-Tertiary deposits include volcanic and alluvial and other sedimentary beds which have accumulated in restricted parts of the area, especially in the south, during Pleistocene to sub-Recent times.

The volcanic rocks include basaltic flows and sheets of tuff and lapilli found in the south-eastern part of the district, where three broad, picturesque, shallow tuff craters are grouped near the head of Shoal Bay, an arm of Waitemata Harbour. The flows are restricted to the margins of Lake Pupuke, which occupies the caldera from which they were poured out, and are prominently exposed along the shore between Takapuna and Milford Beaches (Fig. 18) overlaid by beds of fine-textured material which form a continuous sheet encircling the lake as a low-angle cone. A beautiful section of the tuff and unconsolidated lapilli of this sheet is afforded by quarries on the west margin of the lake (Fig. 16), where they are not less than 50 ft. in thickness and shew especially regular bedding in their upper portions. The remaining two caldera are on the western shores of Shoal Bay, and are breached to admit the sea at high-water to their extensive mud-filled sub-circular basins (Fig. 15). The material of the encircling cones is relatively consolidated and coarser than at

Takapuna, for it includes many large angular fragments of Waitemata sandstone and of basalt, in addition to the finer débris of these rocks.

The period of activity of the Takapuna and Shoal Bay volcanoes may be taken to be approximately that of those of Auckland Isthmus, where the perfect preservation of the cones and craters, the freshness of many of the flows which still show plainly such surface characters as ropy structure, and the manner in which many of the flows have occupied valleys of a very late erosion cycle, all testify to the comparatively recent date of these eruptions. This may best be referred to the later Pleistocene or to sub-Recent times.

Post-Tertiary sediments have only minor importance in the Takapuna-Silverdale area, and for the most part take the form of veneers of flood-plain gravels covering limited river terraces. In the Shoal Bay-Takapuna district, however, there are pre-volcanic estuarine silts of Pleistocene age. Discussion of their origin opens up questions of considerable physiographic interest, so that they will be considered in greater detail in a later Section.

DRAINAGE AND PHYSIOGRAPHIC DEVELOPMENT.

Present Physiography.

Inspection of the map shows drainage which is generally insequent, although, as noted, the valleys of Okura Stream and of the eastern tributaries of Rangitopuni Stream, Lucas Creek, and several other streams, appear to shew structural control in their N.E.-S.W. alignment. Another though different suggestion of such control is afforded immediately south of Albany by two cuesta-like divides each of which has a long gentle slope northward, and a steep scarp approximately 150 ft. in height facing the south. The strike of the rocks from which the divides are carved is transverse to the trend of the latter, and in addition their resistance to erosion does not appear to be superior to that of other rocks of the vicinity, so that it appears probable that the steep faces represent fault-scarps, especially as the north-east trend of the northern one and the south-east direction of the southern accord with the directions of the two dominant fault-systems of Auckland Province (see Bartrum and Turner, 1928, p. 136).

In the present area relief and topographic detail frequently have the usual sympathetic relation to the underlying rocks. The Onerahi rocks generally develop forms which contrast in their subdued nature with the stronger relief of areas of Waitemata beds, especially when the latter comprise the more resistant massive sandstones. In the Silverdale-Dairy Flat district, therefore, where Onerahi beds have their main distribution, the valleys generally are widely flaring and have broad low terraces margining the streams. Where siliceous phases of Onerahi strata outcrop, however, their topographic recognition is impossible. The intrusive serpentines usually fail to cause any noticeable disturbance of the simple contours of the Onerahi beds they invade, although they are sufficiently resistant to protrude in inconspicuous outcrops.

Towards Takapuna, there is rapid descent from high-level maturely-dissected uplands to small bay-head plains along the east

FIG. 1.—Photomicrograph of argillaceous limestone of the Onerahi Series from Okura Quarry, shewing tests of *Globigerina* and other Foraminifera. Magnification 38 diams.

FIG. 2.—Cross-bedded "Parnell Grit" conformably overlying Waitemata sandstones and mudstones north of Deep Creek. A normal fault of small throw (20 ft.) displaces the beds on the left of the photograph.

Photo. C. F. Dixon.

FIG 3 —Fossil log of *Teredo* bored wood in Waitemata sandstones at base of sea cliffs half of a mile north of Deep Creek

Photo C I Dixon

FIG 4 —Limonite filling joints in Waitemata sandstone of shore-platform, Browns Bay, wave erosion has etched the material into strong relief

Photo, C F Dixon

FIG 5—Photomicrograph of limestone from a block included in the "Parnell Grit" at Whangaparaoa Head, shewing a test of *Amphistegina* and remains of Bryozoa and corals. Magnification 46 diams.

FIG 6—Photomicrograph of volcanic tuff constituting a rounded pebble included in the "Parnell Grit" of Whangaparaoa Head, shewing crystals of augite, fragments of a dark aphanitic igneous rock and foraminiferal and molluscan remains set in a matrix of calcite. Magnification 46 diams.

FIG. 7.—Thrusting in Waitemata strata at the north end of Milford Beach The main thrust plane is a little below the middle of the photograph, and the in-bent edges of the lower (sub-horizontal) beds of the main translated sheet are visible on a level with the root of the tree. A second plane of thrusting is shown beneath this in the middle portion, whilst a third is developed still further down on the left beneath the up-turned ends of beds over-ridden by the higher sheet. Blocks of "Parnell Grit" entangled among the normal sediments are marked X.

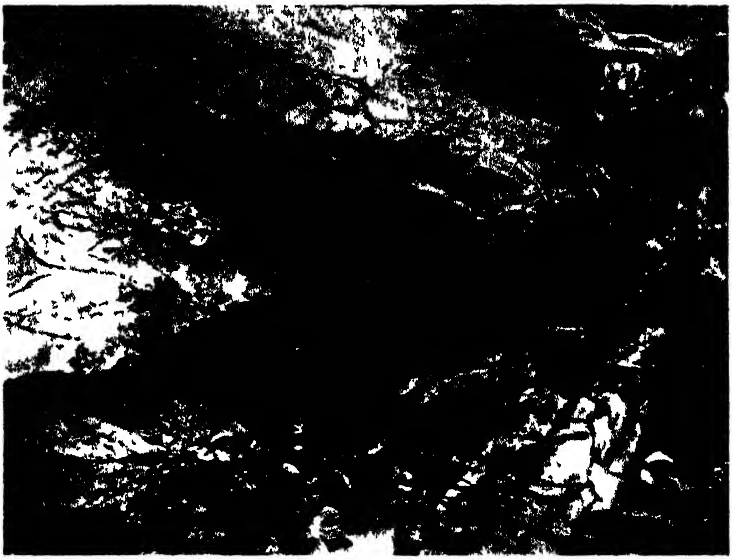


FIG. 8—Details of the main thrust plane of Fig. 7 as seen from the south. The in-drag of the edges of over-riding strata is very well shown.

FIG. 9.—General view, looking west from the shore, of the same thrust as in the last figure. Note the vertical disposition of beds near the left margin of the figure and again towards its right edge (Photograph of Fig. 7 is taken from near this latter); this disposition is believed to be the result of pressure from the south-west causing in-tilting of over-ridden beds adjacent to the curved toe of the advancing overthrust sheet, which has been obstructed by a mass of resistant "Parnell Grit" (beyond right edge of figure).

FIG. 10.—Close-up view of disturbed Waitemata strata seen on the right in Fig. 9, showing the high degree of tilt and distortion where the beds approach resistant beds of "Parnell Grit," which lie beyond the right margin of the photograph.

FIG. 11.—Folded and fractured Waitemata strata, north coast of Whangaparaoa Head.

FIG. 12.—Folding and thrusting in Waitemata beds of sea cliffs south of Huaroa Point, east coast of Whangaparaoa Head. The steeply inclined strip of vegetation (dark) follows a fracture.

Fig. 13.—Contorted Waitemata beds in sea cliffs of the east coast of Whangaparaoa Head.

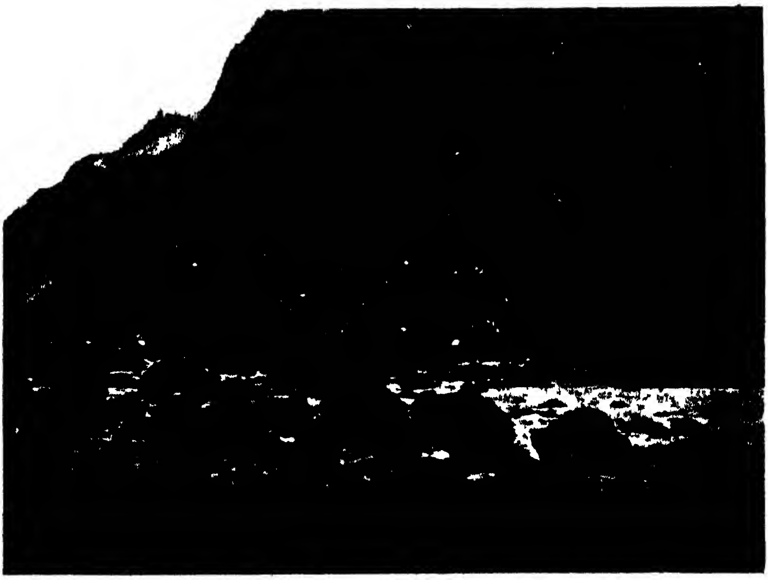


Fig. 14.—Band of "Parnell Grit" (dark) in sea-cliffs south of Huaroa Point, Whangaparaoa Head, fractured and steeply in-dragged by movements accompanying moderately large-scale thrusting.

FIG 15.—View, looking towards its outlet, of the more northerly of the two breached calderas of Shoal Bay, with the cone of Rangitoto in the distance Note the low elevation and steep inward slope of the crater-walls, and the wide mud-filled mangrove-dotted tidal interior.

Photo, C. E. Dixon

FIG 16.—Smale's (formerly Adams') quarry, west side of Lake Pupuke, showing the bedded basaltic lapilli (dark) and tuff of the low rim of this crater lake

Photo, C. E. Dixon

Fig. 17.—Pleistocene clays and silts, "baked" to prismatic white porcellanite by inruptive vesicular basalt beneath them in Adams' (now Smale's) quarry, west side of Lake Pupuke, Takapuna. Photo taken in 1915.

Fig. 18.—Basaltic flow overlying Pleistocene clays (at and below level of hammer) at a height of 3ft. above high water mark in low sea cliffs a little north of Takapuna Beach.

Photo. C E Dixon

FIG 19—Raised beach in foreground, passing in middle distance into a shore-platform 4 ft above sea-level carved in resistant lava and backed by ancient sea cliffs constituted mainly of bedded lapilli View of Black Rock, Milford, taken in 1915 Much of the raised beach has now been removed

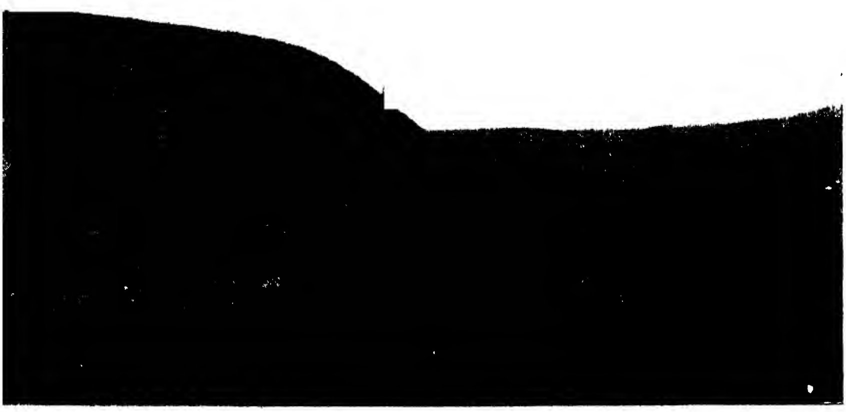


FIG 20—Alluvial flat about 5 ft above sea-level backed by ancient sea cliffs at southern end of Long Beach.

Fig 21 —Photomicrograph of doleritic rock included in the serpentine of Fisherman Creek, showing plagioclase ophitically related to titaniferous augite and a little ilmenite Nicols crossed Magnification 47 diams

Fig 22 —Photomicrograph of schist from the serpentine of Fisherman Creek, showing a large crystal of brown hornblende set in a matrix of granular pyroxene and feldspar Ordinary light Magnification 47 diams

FIG. 23.—Photomicrograph of coarse variety of serpentine from Major Jolly's quarry, White Hills. Large crystals of bastite are surrounded by serpentine derived from olivine and showing typical mesh structure. Nicols crossed. Magnification 47 diams.

FIG. 24.—Photomicrograph of basalt from "horse" included in Waitemata strata, north coast of Whangaparaoa Head. A large phenocryst of olivine, largely altered to calcite and marginal iddingsite, and smaller ones of augite and plagioclase are set in a fairly coarse groundmass of augite, plagioclase and magnetite. Ordinary light. Magnification 47 diams.

FIG. 25.—Photomicrograph of coarse holocrystalline phase from a drusy pocket in Pleistocene basalt of Smale's quarry, west side of Lake Pupuke, Takapuna. Large crystals of ilmenite and augite are prominent in the general colourless mass of plagioclase. Ordinary light. Magnification 34 diams.

FIG. 26.—Photomicrograph of the Smale's quarry basalt. Large phenocrysts of unaltered olivine appear in a relatively coarse pilotaxitic groundmass of plagioclase, augite and ilmenite. Nicols crossed. Magnification 47 diams.

coast, and to the broad aggraded basin of the upper portion of Wairau Stream, which in the past was dammed and probably diverted by the eruptions of Pupuke volcano. West of Pupuke crater-lake, at the head of Shoal Bay, there is a wide plain at an altitude of approximately 40 ft. above sea-level, which is built of flat-lying consolidated tuffs ejected by the volcano, and is drained by a small stream flowing into Shoal Bay. Northward it passes imperceptibly into a broad southern arm of Wairau plain, whilst to the east its level is continued as a plain-like upland carved in Waitemata beds immediately at the head of Shoal Bay, and to the south by a platform, rising gently to higher levels, which is constituted by débris ejected from the northern of the two craters on the west shores of this bay. It is probable that these co-ordinated surfaces are to be correlated with an erosion-level at about the same altitude around the extreme southern and north-western shores of Waitemata Harbour, and traceable as a prominent terrace on the eastern bank of Lucas Creek.

The relation of a 40 ft. bench in close contiguity to an unfilled caldera at Shoal Bay has distinct interest. Its correspondence of altitude with adjacent erosion surfaces is too great to permit unequivocal acceptance of any supposition that, where underlain by tuff, this feature represents an accumulation-surface affected since its initial stage only by colluvial processes. In view of this fact, and of the demonstrated widespread distribution around Waitemata Harbour of an erosion level at a comparable height above sea-level, the writers suggest that the bench on the flanks of the Shoal Bay cone is a portion of this extensive surface; as will be shewn later, it was carved during a relatively distant stage in the physiographic development of the Auckland district. From this the deduction is inevitable that some, at least, of the Auckland volcanoes began their activity in far earlier times than others by which have been buried physiographic features which are part and parcel of the modern topography.

Attention must, nevertheless, be drawn to the difficulties of co-ordination of the various events in the later history of the present district introduced by acceptance of the writers' views. It is shewn in the next Section that if, as is suggested, the volcanic outbursts preceded the formation of the 40 ft. to 60 ft. erosion surface, it is necessary to postulate that an extensive ancestral lowland at least 40 ft. below this erosion level was carved at a stage (3c of the summary at the end of the next Section) when the main movement had long been positive, for, at this horizon, post-Tertiary silts and clays underlie the volcanic débris. Though low-level planation at this stage is indicated by facts elsewhere, it is not shewn to be at all extensive.

On the other hand, if the correspondence of surface level of the volcanic material and erosion surfaces of Shoal Bay is regarded as merely a coincidence, the explanation of the facts is relatively simple (see Section on Later History of Lower Wairau Basin), and the birth of the Shoal Bay-Takapuna volcanoes was by no means so early as is demanded by the alternative hypothesis.

Near the mouth of Kauri Gully, a small stream flowing east from Northcote which has been responsible for the breaching of the southern of the two calderas on the west side of Shoal Bay, there is a

short stretch of surprisingly broad shore-platform, about 200 yds. in maximum width, cut in Tertiary sandstones about 2 ft. below normal high-water level. Its development is abnormal in comparison with adjacent cut-platforms, and cannot be explained as due to recession of sea-cliffs (here about 60 ft. high), because the constituent rocks trend sub-parallel to the shore and shew no apparent differences of hardness along their strike. Furthermore, apparent recession of so large an amount is unknown elsewhere in Waitemata Harbour, unless under conditions similar to those obtaining in the present instance.

The probable explanation of the platform is that at an earlier stage Kauri Gully carved a flood-plain near its mouth, and, in fact, a remnant of a similar plain originally conjoint with the other survives in Sulphur Bay close by. Upon completion of the sub-Recent submergence which has affected the whole of Auckland Peninsula, the shore-line receded rapidly as the veneer of soft unconsolidated alluvium was removed, until stayed by the more resistant and lofty cliffs of Tertiary sandstone beyond the alluvium.

EVOLUTION OF MODERN TOPOGRAPHY.

When viewed from a distant elevation such as Rangitoto, the accordance of general level of the divides of the area now described is so striking that one of the writers (Bartrum, 1922) has elsewhere described the environs of Auckland as a peneplain dissected in consequence of later uplift. Cotton (1922, p. 127, Fig. 130) has similarly applied the term peneplain to the region marginal to the local harbour, but includes as products of the one cycle two erosion levels which are here believed to indicate composite topography. Evidence from elsewhere in Auckland of peneplanation following late Tertiary emergence is clearly afforded by plateaus near North Cape (Bell and Clarke, 1910, p. 614; Bartrum and Turner, 1928, p. 102), whilst Grange (1927, p. 8) describes a peneplain from North Taranaki which is approximately contemporaneous in origin with that of Auckland, and, like the latter, was carved when sea-level was approximately 700 ft. higher than now.

At the close of Waitemata sedimentation, the Kaikoura uplift caused the birth of a broad land-mass which extended both east and west far beyond the limits of the present distribution of Waitemata strata. This may be regarded as the initial stage in the development of the modern composite topography, which clearly has been controlled by post-Waitemata movements of sea-level.

Following this emergence, long-continued erosion developed a wide peneplain which extended many miles east of the present district. Uplift then recommenced and reached a maximum probably not substantially in excess of 600 ft. The modern drainage was initiated during this positive movement, and the land-mass finally reached a stage which usually varies from early to late maturity, mainly under the control of three large stream-systems which probably are tributaries of ancestral consequent streams flowing in a south-east direction, and are themselves partly subsequent upon folds and fractures of the Kaikoura orogeny.

If a suggestion based upon incomplete observations may be proffered, it appears likely that one of the ancestral consequents referred

to followed the lowland depression traceable north-west from Hobsonville, on the north-west shores of Waitemata Harbour, through Kumeu and Kaukapakapa on the northern railway. Its eastern extension is now occupied by the harbour itself.

The three large stream-systems mentioned, with which there is immediate concern, are:—

1. Rangitopuni Stream, which probably joined the early Waitemata River on the low plains east of Kumeu, and shews close approach to N.N.E.-S.S.W. alignment.

2. Okura and Weiti Streams representing the betrunked portions of a dismembered river flowing to the east on the south side of Whangaparaoa Peninsula.

3. Orewa Stream, which enters the sea north of this latter peninsula, is also the betrunked remnant of a much larger stream.

The positive movement which commenced upon attainment of the peneplanation described, was interrupted by several well-marked periods of standstill, during which the streams became graded with respect to appropriate sea-level, and cut wide valley-floors which now constitute terraces and small plateaus at various altitudes. Some of them are very extensive and can be correlated with similar erosion-levels in other parts of Auckland Province. The highest is somewhat poorly demonstrated and may, in fact, be merely a lower portion of the early peneplain described above. It is indicated at a height of about 300 ft. to 350 ft. above sea-level by benches cut on the walls of the valleys of tributaries of Lucas Creek and Okura Stream where they head against Pukeatua, and by the remarkably even summit of a divide which extends for nearly 5 miles south from Tirohanga Hill almost to Pupuke Lake.

At a height of approximately 100 ft. to 120 ft. above sea-level, however, there are extensive uplands near Auckland City on both the northern and southern shores of the harbour, which have broad sometimes plateau-like interfluves locally covered by volcanic accumulations. This erosion-level includes almost the whole of the Takapuna-Devonport Peninsula, and is represented also by small terrace-remnants in tributary-valleys near the head of Lucas Creek. It almost certainly is to be correlated with marine benches noted by Smith (1881, p. 409) at a height of 100 ft. above sea-level at several points near Auckland and around Kaipara Harbour further north.

The next erosion surface is at a height of 40 ft. to 60 ft. above sea-level, and is by far the most extensive ancient flood-plain near Auckland. It is present as terraces in practically all the valleys of the district described in this paper, especially near Albany, in Rangitopuni and Orewa Valleys and near the limit of tidal waters in Okura Stream, and is preserved in wide plain-like remnants on the southern and western shores of Waitemata Harbour approximately west of Kauri Point. Watchman Island is interpreted as a remnant of this plain.

At New Lynn, Hobsonville, and other places, there is demonstration that this 40 ft. to 60 ft. level represents far more than a period of standstill during the major uplift we have discussed. Oscillations occurred prior to this standstill and, as will be shewn, were of considerable magnitude. Near New Lynn and Point Chevalier on the

south-west shores of Waitemata Harbour, the 40 ft. to 60 ft. bench is underlain in part by Tertiary sandstone, and in part by younger highly plastic clays which contain many richly-carbonaceous layers, and often shew stems and roots of plants in the position of growth. Near the abandoned brick-works at Hobsonville there are also some fine-textured gravel beds belonging to this formation. These clays have a maximum thickness, where examined, of over 40 ft., and rest on a slightly-undulating surface of Tertiary sandstones. At New Lynn they have suffered local tilt in common with the surface on which they rest, though it has not been determined whether this is in consequence of folding or fracturing.

These beds are interpreted as deposits formed in lakes or on the swampy floors of the valleys of sluggish streams during the progress of very slow subsidence.

It is thus clearly indicated that prior to the development of the extensive 40 ft. to 60 ft. erosion surface, there was emergence which raised the Auckland area until sea-level relative to adjacent land was much as to-day, or probably a little lower. These conditions allowed the excavation of valleys subsequently infilled to a greater or less extent by more recent clays during a slow negative movement of the strand,* and it will be shewn in discussion of the history of the Lower Wairau Basin, that the Shoal Bay-Lake Pupuke area possibly was also eroded at this period to form a hollow a little below what is present sea-level. The upward limit of the filling of the valleys or hollows has not been determined, but it is of importance to note that the tilt of the New Lynn beds has been observed in cases distinctly to be opposed to the slope of the surface subsequently carved upon them. This indicates that the flexure or faulting which caused such tilt was approximately concomitant with the period of standstill which closed this phase of minor negative movement.

In addition to the previous examples of erosion-benches, terraces about 15 ft to 20 ft. above sea-level are common towards the mouths of most of the streams, and should probably be correlated with raised beaches at that level which have been noted at various places around the coasts of Auckland by Smith (1881, pp. 403-410) and others.

Henderson (1914; 1924, p. 580) believes that all shore-terraces not above 120 ft. in elevation above sea-level are due to comparatively recent uplift subsequent to the submergence responsible for the characteristic drowned topography of North Auckland, but from evidence near Auckland it appears that the submergence was one of the most recent events, for although subsequent uplift has probably occurred, yet its magnitude does not exceed 5 ft. in numbers of instances, and it has followed the submergence so closely that the only wave-cut platforms developed and preserved are on exposed locations.

Further facts from other sources are corroborative of this conclusion. In the first place, the logs of bores put down by the Auckland Harbour Board, kindly shewn one of the writers by Mr. Hamer,

---

*Mr C W. Firth, who is at work on an area east of Auckland City, has informed one of the writers that these conclusions are precisely those he has come to from evidence near Beachlands, about 14 miles east of Auckland.

formerly Engineer to the Board, shew that broad sub-aqueous benches exist a few feet below low-water level, buried beneath marine filling, near the mouths of the various small streams which debouch on to the central waterfront from the low hills on which Auckland City is built, whilst the former stream-channels are represented by deep narrow infilled troughs. This indicates that flood-plains were carved at this level prior to the submergence, and it is highly probable that these accord in period with that indicated, as has already been described, on the west shores of Shoal Bay. It is believed that the lava-flow constituting the "Black Reef," near Point Chevalier, which extends over half-way across the harbour towards Kauri Point, followed a trench dissecting one of these now-submerged flood-plains Again, Lucas Creek and numbers of small streams draining the plain-like lowlands near and north-west of Hobsonville are fringed by terraces of the 40 ft. cycle, whilst they have relatively wide deep trenches which are now largely infilled by mangrove swamp and other sedimentary filling. As will be shewn, the same fact applies to Kauri Gully on the west coast of Shoal Bay, and it is inconceivable that such trenches have been excavated by the modern streams unless when the sea was at a much lower level than to-day. The terraces thus do not demonstrate uplift subsequent to submergence.

Other supporting evidence comes from the lowlands fringing Manukau Harbour near Papatoetoe, which are built mainly of pumice-silts deposited in a great early estuary of the Waikato River, and are surmounted here and there by more recent volcanic accumulations. Much of the lowland does not exceed 40 ft. in altitude. It is bordered east of Papatoetoe by hills eroded from Tertiary rocks and drained by streams which often are margined near their debouchure by flights of terraces which are continued on to the lowland areas. Had sub-Recent uplift subsequent to the negative movement now discussed been general, it seems inevitable that marine terraces, in common with others ascribed to such uplift, should be recognizable somewhere in the vicinity of those due to the streams. Yet abandoned sea-cliffs or other signs of shore-line processes have not yet been recognised in that district, although it has been closely examined.

According to the views of the present writers, a considerable and rapid elevation took place as a culmination of the interrupted positive movement just described, and the streams deeply entrenched themselves in their flood-plains. Its rapidity is evidenced by the steep walls of the many narrow valleys drowned by succeeding submergence, and now largely filled up to sea-level by fine-textured sediment. This latter negative movement was apparently of a eustatic kind, for it has affected the greater part of New Zealand, if not the whole, and gave rise to highly-embayed coastlines illustrated by Waitemata Harbour, and the tidal estuaries of Okura, Weiti, Orewa, and other streams of the district described in this paper. As can be judged from preceding statements, its magnitude was slightly greater than that of the culminating phase of uplift it followed.

It is difficult to make an exact quantitative estimate of the vertical movement involved, for reconstruction of the cross-profile of drowned valleys furnishes inexact data, and indicates only that it may well be of the order of 150 ft. or 200 ft., a figure which Hender-

son (1924) shews is the minimum demanded by facts in other parts of New Zealand. Henderson (1924) summarises many observations dealing with the depth of deposits in various depressed areas, but in many of these instances the filling was initiated, if not completed, long prior to the submergence now under consideration, so that the data have little bearing on the present problem.

Since the submergence was completed waves have been actively cutting back the more exposed portions of the coast, while sheltered bays have been partially filled by the progradation of crescentic pocket-beaches and by the creation of barrier-beaches behind which lagoon-deposits have accumulated. In Shoal Bay barrier-beaches of this type have been built on a perfect though miniature scale, and are now receding, exposing lagoon-deposits of mud on their seaward face. Curved spits are also prominent near the mouth of Weiti Estuary and other larger embayments.

Cliff-recession has been excessive along the northern coast of Whangaparaoa Peninsula, which is exposed to the full force of north-east gales, as may be guaged from the fact that at the head of Maori Bay the divide has been driven back at least a mile from its original position (estimated by reconstruction of the symmetrical divide usual in areas of Waitemata rocks), until all that remains is a strip of sandstone 10 yds. wide and only about 15 ft. above sea-level. Similarly, in the neighbourhood of Murray and Brown Bays on the east coast of the district, the proximity of the present divide to the shore suggests that here too wave erosion has been very active.

It has been stated that the final diastrophic movement in the decipherable history of the Takapuna-Silverdale area is a sub-Recent elevation of about 5 ft. This is evidenced by raised beaches at this height above storm-beach level at intervals between Takapuna Beach and Okura South Head, whilst just south of this latter locality cemented shore-conglomerates with rounded boulders of Waitemata sandstone are exposed at the mouth of two small streams at about 3 ft. or 4 ft. above high-water mark. At Black Rock, also, between Takapuna and Milford Beaches, there is an elevated shore-platform of basaltic lava, associated with raised beach deposits and abandoned sea-cliffs (Fig. 19), whilst similar ancient sea-cliffs of soft Tertiary sandstone occur also at the south end of Long Bay (Fig. 20), six miles further north. These cliffs and platforms have been so little affected by sub-aërial erosion that they testify clearly to the recent date of this final minor elevation.

For convenience of reference the sequence of events which have moulded the present topography may be summarized thus:—

(1). Main uplift of the Kaikoura orogeny.

(2). Peneplanation.

(3). Uplift, varied by at least one minor oscillatory movement in the reverse direction, and punctuated by periods of approximately constant sea-level which are represented by:—

(a). "350 ft." erosion surface.

(b). "100 ft. to 120 ft." erosion surface.

(c). "40 ft. to 60 ft." erosion surface. A slight negative movement of the strand immediately preceded this standstill.

(d). 20 ft. to (?) -10 ft. erosion surfaces represented by 20 ft. terraces and, as a later product, by now-submerged platforms.

(4). Acute elevation represented by trenches now drowned.

(5). Submergence followed by small sub-Recent uplift.

THE LATER HISTORY OF WAIRAU BASIN.

In the Takapuna-Shoal Bay area there are numerous localities where white silts or clays (often capped by a carbonaceous layer 6 ins. or more in depth) occur usually at a foot or two above high-water level, preserved beneath basaltic flows or tuffs. The chief exposures are on the west shore of Shoal Bay, just east of the southern caldera of that district, and on the outer margins of the Lake Pupuke cone, as along the shore between Takapuna and Milford Beaches (Fig. 18) and in artificial excavations such as a shaft sunk in search of water in Wairau Valley north-west of the lake, and several quarries west and south of it.

The silts generally are very fine-grained and plastic, and contain impressions of sedge-like plants along with stumps and fallen branches of coniferous and other trees up to 10 ins. in diameter. The latter are seen in the position of growth, as they were overwhelmed by the lava, at the north end of Takapuna Beach, and in a quarry at the head of Shoal Bay near the Orphanage. In the latter place what are believed to be the silts are higher above sea-level than elsewhere, reaching an elevation of about 12 ft., and it is possible that here they represent, not bedded silts, but ancient residual clays derived from Waitemata sandstones such as form a small peninsula immediately east of the quarry. In quarries on the west margin of Lake Pupuke these beds have been invaded and disordered by lavas which have baked them into white porcellanite; this generally shews perfect prismatic jointing in addition to less regular shrinkage cracks (Fig. 17). Along the shore between Takapuna and Milford Beaches the silt is usually followed upwards by a thin layer, about 1 ft. in depth, of fragmental volcanic material erupted prior to the outpouring of covering lavas. At one spot, however, it is overlain by a basement conglomerate beneath the lavas consisting of well-rounded pebbles and boulders up to 6 ins. in diameter essentially of basalt, which appears, from its relatively non-vesicular character, to have been worn from a flow, but including also an occasional pebble of greywacke. The conglomerate is at a height of about 1 ft above high-water mark, and represents an ancient beach formed of débris worn from early products of the adjacent eruption. It has especial interest in that it shews that the silts were exposed to vigorous wave-erosion either when volcanic activity commenced, or shortly after this; upon them a very gently-shelving cut-platform must have been developed in the protection of adjacent headlands of recently outpoured resistant volcanic rock.

The greywacke pebble probably represents a fragment from underlying beds brought up by the eruption, though it may conceivably have been carried to the area entangled in drift-wood. Amongst the ejecta of the southern of the two Shoal Bay volcanoes, occasional polished and rounded pebbles of the same Trias-Jura rock are dis-

coverable; the readiest explanation of their presence is that they have been disrupted from underlying Tertiary conglomerates such as outcrop at the base of the Waitemata Series at Motutapu, about 9 miles north-east of Takapuna.

In reconstructing the topographic conditions which obtained when the pre-volcanic silts described were accumulating, it is necessary first to consider certain features of the present topography. It will be recollected that the aggraded floor of Wairau Valley has a southern arm which is almost continuous with a plain, built of volcanic tuff, which extends north-west from the head of Shoal Bay at approximately 40 ft. above sea-level, and is separated by an imperceptible divide from water flowing north to Wairau Stream. From this Shoal Bay-Wairau Plain, Wairau Stream turns sharply at right angles, following the contact between the low-lying volcanic accumulations and elevated Tertiary hills north-west of them in a north-east direction to the sea. Half a mile from the open sea it is held up by a barrier of hard basalt, through which its falls have receded a comparatively short distance, whilst its upper reaches are graded with respect to this local base-level.

The various facts suggest that in Pleistocene times, before the volcanic outbursts had begun, and whilst the sea was within a few feet of its present level, the ancestral Wairau Stream flowed south into a wide shallow estuary of which Shoal Bay now represents the diminished remnant. Sedimentation in this sheltered sheet of water built up deposits which locally arose above sea-level and furnished dry land on which coniferous trees (some of which appear to have been kauri) and other vegetation flourished.

The south-east barrier of this estuary is preserved as the Takapuna-Devonport peninsula of Tertiary rocks, but the barrier east of Pupuke crater has disappeared beneath the sea. This may have been an isthmus of Tertiary sandstone destroyed during the vigorous retrogression which has affected the adjacent coast, or perhaps a wave-built accumulation in the form of a tombolo uniting islands of the Takapuna-Devonport peninsula with the mainland north of Milford, for to-day a similar tombolo unites the former island of Devonport with Takapuna at Narrowneck. Whether isthmus or tombolo, however, the connection has been shewn to have been destroyed by shoreline retrogression prior to the main period of eruption of Pupuke crater.

Volcanic lavas and ejecta subsequently covered these soft estuarine silts and allowed their preservation; at the same time they temporarily ponded Wairau Stream, and ultimately allowed its diversion to the north-east. The continuation of the level of Wairau Plain as an erosion-level on the north-western margin of Shoal Bay, which has been mentioned earlier, indicates that Wairau Stream continued its ancestral course for some considerable time during a period when sea-level remained approximately 30 ft. higher than now, but was finally captured by a small stream working headward from the eastern coast of the area along the contact between volcanic and Tertiary beds.

Certain evidence points clearly to the fact that the deposition of the estuarine silts and the volcanic eruptions preceded the phase of

major submergence of Auckland Province. This is furnished best by Kauri Gully, a small stream flowing from the west into Shoal Bay at the breach in the rim of the southern crater. Its valley is relatively straight and wide, and has been rejuvenated so as to be characterized by very steep walls in its lower portion. These steep and lofty walls are carved alike from Tertiary sandstones and volcanic ejecta, and descend uninterruptedly to disappear beneath a flat floor covered by the deep muds of a mangrove swamp. Conditions are such that wave-erosion cannot be considered as a factor in the development of these slopes, and it appears impossible to ascribe them, in conjunction with the considerable width of the floor of the valley, to the work of so small a stream as Kauri Gully if controlled by a base-level approximately that of to-day. The deduction therefore seems inevitable that a V-like valley was excavated during a phase of acute elevation which succeeded the ejection of the volcanic débris, and was followed by submergence which caused the drowning of the narrow trough. Corroborative evidence is yielded by the lower portion of Wairau Valley, where a similar wide trench has been carved below sea-level partly in lava from the neighbouring volcano, subsequently submerged and then largely infilled by estuarine sediments.

It has been shewn that there is doubt as to whether the ancient Wairau Estuary originated just prior to the development of the 40 ft. to 60 ft. erosion surface (Stage 3c of the summary in the last Section) or later. The writers have already detailed their reasons for suggesting that its origin should be referred to this earlier rather than to the later stage, and here wish merely to enlarge on the alternative possibility that arises if these reasons are set aside. This possibility is that the Lower Wairau Estuary came into existence during the last phase (3d of an earlier Section) of the general uplift which followed post-Tertiary peneplanation, so that it was approximately synchronous in origin with the Kauri Gully flood-plain. This hypothesis has the merit of simplicity, for evidence has already been presented which demonstrates that extensive low-lying flood-plains, now largely submerged, were carved at that period in parts of the valley of the early Waitemata River.

PETROGRAPHY.

ULTRABASIC AND ASSOCIATED INTRUSIVE ROCKS.

As previously shewn, doleritic rocks with serpentines and associated ultrabasic types invade the Upper Cretaceous Onerahi strata. Bartrum (1924, pp. 150-152) has recognised and described from the adjoining Riverhead-Kaukapakapa district most of the types discovered in the present area, so that little detail is here necessary.

Serpentines.—These are the prevailing type of rock, and have been derived from peridotites ranging from harzburgite to dunite. No unserpentinized remnants of the original minerals exist in any of the rocks encountered, though at Parakakau and elsewhere just north of the present district it is otherwise.

Harzburgite-serpentine is the prevailing variety (Fig. 23), and by reduction in the quantity of bastite present grades into dunite-

serpentine. Picotite is by no means an infrequent accessory constituent, though grains of chromite are rare; the former is especially plentiful in a coarse bastite-rich serpentine from Matthews' quarry, 3 miles south of Silverdale. Many of the serpentines have veinlets of secondary chrysotile and sometimes of carbonates.

A high degree of variation in facies may be displayed in the one relatively small intrusive mass, as has already been shewn by Bartrum (*loc. cit.*) for that at Parakakau. In the vicinity of Wainui Cemetery in Upper Orewa Valley, for example, whilst serpentinized dunite is the prevailing type, one specimen collected contains about 10 per cent. of partially-altered large crystals of diallage and enstatite set in the usual felted mass of serpentine, shewing that the rock of the intrusion is locally an olivine-rich lherzolite. Other specimens from this intrusion include veinlets composed of finely-fibrous serpentine in very coarse-bladed crystals, and a rock described by Bartrum (*loc. cit.*) as consisting of chlorite with abundant sphene and epidote. The chlorite has the lattice-structure usually characteristic of antigorite, but is not this latter mineral, for it is optically positive and has negative elongation. Masses of chrysotile in bladed aggregates similar to those at Wainui Cemetery occur also in the bastite-serpentine of Matthews' quarry, whilst, from this same type of rock at Major Jolly's quarry 3½ miles west of Silverdale, two small nodules were collected, one of coarse-grained bastite, with a little serpentine pseudomorphous after olivine, and the other of a fibrous chlorite in fairly large blade-like aggregates which appears to be clinochlore.

An interesting rock was unearthed in "serpentine" in the valley of Kaitoke Creek east of Flat Top Mountain, 8 miles north-west of Silverdale, in the area already described by Bartrum (1924). Some unusual alteration has affected the chief constituent of the rock, causing it to be so reduced in translucency that its polarization-tints are almost obscured in most parts of the slice examined. This constituent appears to be olivine in long prisms arranged in coarse radial aggregates, though the application of decisive optical tests proved impracticable. When not in radial prisms the mineral shews its normal alteration to serpentine with the usual mesh-structure, whilst a felt of small tufts of serpentine invades the radiate material and appears to be its alteration-product. Bastite is present in moderate quantity amidst such serpentine, though not in intimate association with the radial olivine.

An unusual rock was given the authors by Mr. H. T. Ferrar of the New Zealand Geological Survey, and is said to outcrop outside the present area near the junction of Kaukapakapa-Silverdale and Kaukapakapa-Parakakau roads. This is a pyroxenite composed dominantly of enstatite in crystals about 4 mm. to 5 mm. in average diameter, and in common with other constituents almost unaffected by alteration. Besides the enstatite there is a minutely lamellar fibrous pyroxene which does not lend itself to exact microscopic determination, but appears to be diallage rather than an intergrowth of orthorhombic and monoclinic varieties. Slightly serpentinized subsidiary olivine is entangled in the interstices between the larger crystals; it is rarely enclosed in the latter. Narrow strings of serpentine penetrate the pyroxene, whilst a little secondary pyrite is also present.

The effect of pressure is seen in the granulation of the margins of some of the crystals and bending of the lamellae of the monoclinic pyroxene.

Anorthosite.—The writers are again indebted to Mr. H. T. Ferrar for a chip of an anorthosite which was collected from boulders at Davidson's farm, a few miles west of Silverdale, and consists of predominant anorthite enwrapped ophitically by a small quantity of interstitial diallage, but contains also large crystals of what appears to be enstatite deeply oxidized and stained by haematite.

Dolerites and Associated Rocks.—Bartrum (1920a, p. 420; 1924, p 152) has already described a dolerite from the swinging basin at Silverdale and an epidiorite and a dolerite from Upper Orewa. Additional occurrences include boulders of epidiorite, similar to that from Upper Orewa, at Davidson's farm west of Silverdale, and of dolerites and other somewhat less basic intrusive rocks, along with lavas, at Orewa Heads.

One coarse holocrystalline dolerite is very different in facies from any other rock of the area. It is not ophitic, but contains very abundant idiomorphic pyroxene and brown barkevicitic amphibole, which are enclosed by coarse plates of plagioclase, along with a moderate quantity of very coarse ilmenite, often in typical skeleton crystals, a little more or less chloritized intensely absorptive brown biotite, and very numerous long needles of apatite. Chlorite is moderately plentiful. The pyroxene is a strongly titaniferous variety, and occurs in stout crystals usually about 1.5 mm. in length, but as much as 6 mm. The barkevicite is sometimes enclosed by the augite, but more often enwraps this latter, occasionally being outgrown upon it. Its pleochroism varies from brownish-yellow to deep reddish-brown, and its extinction angle is 17°. The variety of plagioclase was not determined with certainty, though it is at least as basic as acid labradorite. It is considerably weathered, and in places is replaced by calcite and an isotropic mineral which is identified as analcite. The latter was at first suspected to be opal, but was not dissolved upon treatment with caustic potash, whilst it gelatinized with hydrochloric and nitric acids, yielding cubes of salt only with the former. It generally occurs as small irregular patches in the feldspar, but larger masses as much as 3 mm. in diameter were also observed.

Others of the Orewa boulders furnish a considerably crushed coarsely crystalline quartz-augite porphyrite, or possibly dolerite, for the variety of plagioclase was not precisely determinable, and in uncrushed remnants the long laths of this latter mineral are ophitically related to pseudomorphs after augite. Quartz is not infrequent in fairly large crystals, whilst there are a few unaltered flakes of brown biotite. Generally, however, this last mineral has been converted to scales of chlorite, which forms some conspicuous irregular foliae. Apatite is in moderate quantity in very long needles, whilst ilmenite is common usually in string-like aggregates. The augite is an almost colourless variety, and now is largely represented by calcite with a little chlorite. It is somewhat subordinate in amount to the plagioclase, which is not less basic than medium labradorite.

A further rock represented in the Orewa Heads boulders appears to be a feldspathic porphyrite, with not more than 15 per cent. of partially-chloritized almost colourless augite, plentiful coarse ilmenite and numerous tiny prisms of apatite. Secondary calcite is very abundunt, usually in fairly large nests. The plagioclase is weathered and could not be determined with exactness. It seems to be a variety approximating acid andesine, and is in large unoriented laths about 0.7 mm. in length.

Several andesitic lavas were recognized in the Orewa débris. They are coarsely amygdaloidal, some of the amygdules exceeding 6 mm. in diameter. Advanced weathering again militates against their precise determination.

One type is an aphyric mass of irregularly-disposed laths of plagioclase (? basic andesine), generally less than 0.1 mm. in length, sub-ophitically entangling about 10 per cent. to 15 per cent. of pale greyish-green augite and enclosing about 7 per cent. of iron-ore (largely magnetite). The plagioclase is generally replaced internally by an isotropic material resembling opal, and by a little calcite.

Another amygdaloidal lava has a very open-textured lattice of laths of acid labradorite about 0.2 mm. in length, with abundant chlorite between the laths, and a considerable number of small pseudomorphs of haematite, chlorite and sometimes calcite, apparently after olivine. The laths of plagioclase have been considerably bent by pressure. In this, as in the other lava, the amygdules are filled by calcite crystallized upon an early thin lining of chlorite.

Inclusions in the Serpentine of Fisherman Creek.—In an outcrop of serpentine exposed in a small quarry at the head of Fisherman Creek, on the east side of the main south road, about 1½ miles south of Silverdale, there are several interesting inclusions of greywacke, schist, dolerite, and probably other types of igneous rocks.

The only igneous rock sectioned is a moderately fine-textured dolerite (Fig. 21) with somewhat lath-shaped crystals of plagioclase (basic labradorite) ophitically enwrapped by about 40 per cent. of pale-grey augite, which occasionally shows incipient uralitization. Iron-ore (ilmenite) is in small amount.

The schist (Fig. 22) is composed essentially of narrow bands rich alternately in plagioclase and diopside, along with foliae consisting of streaked-out porphyroblasts of brown hornblende. The plagioclase is andesine-labradorite, and usually shows albite twin lamellae; it forms a mosaic with grains of diopside and is considerably in excess of this latter. The grain-size is variable laterally, but in coarser portions is about 0.04 mm. in diameter. There are some serpentine and carbonate pseudomorphs after olivine, along with ramifying strings of serpentine, which probably represent injected peridotitic material. In addition, a single porphyroblast of almost colourless diopside was noted; it appears as if it is intergrown with tiny flakes of brown hornblende, but the true relationships between the two minerals could not be determined. Pyrite is plentiful in association with the amphibole; this latter is only sparsely present in the general mosaic of the schist. Sieve-structure, which is so general in similar metamorphic rocks, is absent.

Albany Conglomerates.—The petrography of the Albany conglomerates has already been described by Bartrum (1920; 1924); no fresh types have been added during the present investigation.

Basalt from Whangaparaoa.—As noted in an earlier section, a basalt was found as a large mass involved in acute dislocations of Tertiary (Waitemata) strata at Whangaparaoa. It is possibly a considerably altered representative of a basalt, said to be from Silverdale, described by Sollas and McKay (1906, p. 158).

The basalt (Fig. 24) is characterized by a moderate number of rather small phenocrysts of faintly pleochroic titaniferous augite, which are enclosed by a highly-feldspathic matrix of basic plagioclase (labradorite-bytownite), pinkish titaniferous augite and a moderate quantity of magnetite. The augite is generally in idiomorphic crystals shewing hour-glass structure. Calcite and chlorite are abundant secondary products. The olivine is usually represented by pseudomorphs of pleochroic green to almost colourless fibres or cleaved plates of iddingsite, with a little calcite.

Igneous Rocks of the Parnell Grit.—As has previously been noted by Fox (1902) and Mulgan (1902), the fragments of volcanic rock which constitutes a large portion of the Parnell Grit are nearly all andesites, though trachyte has been described by Bartrum (1917).

The andesites are typically porphyritic with large phenocrysts of plagioclase and often of augite or hypersthene set in a groundmass of laths of plagioclase, granules of pyroxene and grains of magnetite. A little olivine has been noted in a type described by Bartrum (1917).

Pleistocene Basalts.—The basalts from Lake Pupuke (Fig. 26) are holocrystalline rocks with numerous phenocrysts of olivine set in a groundmass consisting of plagioclase, titaniferous augite and about 4 per cent. of ilmenite, the plagioclase (medium labradorite) being in decided excess of the other constituents. The grain-size is a little variable, though relatively coarse, for the laths of feldspar generally average about 0.2 mm. in length. Fluxional arrangement of these latter is not infrequent. The olivine is usually in small sub-idiomorphic crystals, though in occasional flows crystals as much as 3 mm. and more in diameter are prominent.

On the west side of the lake the lava sometimes has drusy nests of coarsely holocrystalline material (Fig. 25), perhaps owing its coarseness of grain to accumulated volatile constituents. Sharp, elongated though small prisms of pyroxene, and occasionally olivine, project into the tiny druses. The pyroxene is a titaniferous variety with the usual hour-glass structure, and is subordinate to the plagioclase. It is sometimes bordered by aegirine-augite, of which there are also occasional isolated crystals. Olivine is not plentiful, but ilmenite is prominent in characteristic skeleton crystals along with long needles of apatite. Radial aragonite is sometimes found as a filling of vesicles of the associated lavas.

A slide of vesicular material from the southern of the two Shoal Bay craters shows a dense, largely glassy matrix crowded with rod-like crystallites, laths and prisms of plagioclase and pyroxene in small number and a moderate quantity of iron-ore (? magnetite). Irregularly-shaped phenocrysts of olivine of varied size are common,

whilst titaniferous augite is fairly plentiful, usually in small prismatic phenocrysts, though sometimes in large irregular crystals. The olivine has frequently been resorbed at the margins, yielding place to granular pyroxene, which occasionally forms definite outgrowths upon the enclosed mineral. One large crystal of augite about ½ in. in diameter was picked out of the débris of the cone, and on sectioning showed similar reaction-zones developed from enclosed olivine.

In quarries on the west margin of Lake Pupuke nodules of olivine up to 1½ in. in diameter are plentiful amidst the lapilli. An analysis of the mineral is published below by kind permission of Dr. J. Henderson, Director of N.Z. Geological Survey.

ANALYSIS.

SiO_2	41.53
Al_2O_3	0.42
Fe_2O_3	0.10
FeO	8.51
MgO	47.33
CaO	0.31
Na_2O	0.11
K_2O	nil.
H_2O+	0.24
H_2O-	0.21
CO_2	nil.
TiO_2	0.08
P_2O_5	trace
V_2O_3	nil.
S	0.02
Cr_2O_3	0.20
NiO	0.44
CoO	0.05
MnO	0.15
SrO	nil.
BaO	nil.
	99.70

(Analysis of olivine from nodules in Takapuna Borough quarry near the junction of Tauroto and Northcote roads, west margin of Pupuke Lake, Takapuna. Analyst, F. T. Seelye.)

LITERATURE CITED.

BARTRUM, J. A., 1917. Additional Facts concerning the Distribution of Igneous Rocks in New Zealand, *Trans. N.Z. Inst.*, vol. 49, pp. 418-424.

—— 1920. The Conglomerate at Albany, Lucas Creek, Waitemata Harbour, *Ibid.*, vol. 52, pp. 422-430.

—— 1920a. Additional Facts concerning the Distribution of Igneous Rocks in New Zealand: No. 2, *Ibid.*, vol. 52, pp. 416-422.

—— 1921. Notes on the Geology of Great Barrier Island, *Ibid.*, vol. 53, pp. 115-127.

BARTRUM, J. A., 1921a. A Conglomerate at Onerahi, near Whangarei, Auckland, New Zealand, *Ibid.*, vol. 53, pp. 128-130.

—— 1922. Physiographic Notes on Auckland, *New Zealand Nature Notes*, Austr. Ass. Adv. Sc., Wellington, 1923.

—— 1924. The Geology of the Riverhead-Kaukapakapa District, Waitemata County, Auckland, *Trans. N.Z. Inst.*, vol. 55, pp. 139-153.

—— 1924a. The Igneous Rocks of a (?) Tertiary Conglomerate near Mangapai, Whangarei Harbour, New Zealand, *Proc. Austr. Ass. Adv. Sc.*, vol. 16, Wellington, 1923, p. 345 (abstract).

—— 1924b. An Account of the Stratigraphy of the Riverhead-Kaukapakapa District, Waitemata County, Auckland, New Zealand, *Ibid.*, p. 346 (abstract).

BARTRUM. J. A., and TURNER, F. J., 1928. Pillow-Lavas, Peridotites and Associated Rocks of Northernmost New Zealand, *Trans. N.Z. Inst.*, vol. 59, pp. 98-138.

BELL, J. M., and CLARKE, E. de C., 1909. The Geology of the Whangaroa Subdivision, *N.Z. Geol. Surv. Bull.* No. 8 (n.s.).

—— 1910. A Geological Reconnaissance of Northernmost New Zealand, *Trans. N.Z. Inst.*, vol. 42, pp. 613-624.

BENSON, W. N., 1921. Recent Advances in the Geology of New Zealand, *Austr. Ass. Adv. Sc.*, Pres. Address, Section C, Hobart, 1921.

—— 1923. Palaeozoic and Mesozoic Seas in Australasia, *Trans. N.Z. Inst.*, vol. 54, pp. 1-62.

—— 1924. The Structural Features of the Margin of Australasia, *Ibid.*, vol. 55, pp. 99-137.

—— 1926. The Tectonic Conditions accompanying the Intrusion of Basic and Ultrabasic Rocks, *Mem. Nat. Acad. Sc.*, vol. 19, Mem. 1.

COTTON, C. A., 1916. The Structure and Later Geological History of New Zealand, *Geol. Mag.*, dec. 6, vol. 3, pp. 243-249, 314-320.

COX, S. H., 1881. Geology of the Rodney and Marsden Counties, *Rep. Geol. Explor. during 1879-80*, pp. 13-39.

—— 1882. North Auckland District, *Rep. Geol. Explor. during 1881*, pp. 17-41.

FERRAR, H. T., 1920. Whangarei Subdivision, *14th Ann. Rep. (n.s.) N.Z. Geol. Surv.*, pp. 4-5.

—— 1924. Rodney Subdivision, *18th Ann. Rep. (n.s.) N.Z. Geol. Surv.*, pp. 6-7.

—— 1925. The Geology of the Whangarei-Bay of Islands Subdivision, *N.Z. Geol. Surv. Bull.* No. 27 (n.s.).

—— 1925a. Rodney Subdivision, *19th Ann. Rep. (n.s.) N.Z. Geol. Surv.*, pp. 6-8.

FOX, C. E., 1902. The Volcanic Beds of the Waitemata Series, *Trans. N.Z. Inst.*, vol. 34, pp. 452-493.

GRANGE, L. I., 1927. The Geology of the Tongaporutu-Ohura Subdivision, *N.Z. Geol. Surv. Bull.* No. 31 (n.s.).

HECTOR, J, 1884. Progress Report, *Rep. Geol. Explor. during 1883-84.*

—— 1886. Progress Report, *Rep. Geol. Explor. during 1885.*

—— 1888. Progress Report, *Rep. Geol. Explor. during 1887-88.*

HENDERSON, J., 1914. Coal Possibilities of the Warkworth District, *8th Ann. Rep. (n.s.) N.Z. Geol. Surv.*, pp. 157-158.

—— 1924. The Post-Tertiary History of New Zealand, *Trans. N.Z. Inst.*, vol. 55, pp. 580-599.

—— 1924a. The Structure of the Taupo-Rotorua Region, *N.Z. Journ. Sc. and Techn.*, vol. 6, pp. 270-274.

HOCHSTETTER, F. von, 1864. Geologie von Neu-Seeland, *Reise der Oster. Freg. Novara*, Geol. Theil, Bd. 1, Ab. 1.

MCKAY, A., 1884. On the Occurrence of Serpentinous Rocks as Dykes in Cretaceo-Tertiary Strata near the Wade, Auckland, *Rep. Geol. Explor. during 1883-84*, pp. 99-101.

McKay, A., 1884a. On the Relations of the Tertiary and Cretaceo-Tertiary Strata on the Coast-line between Auckland and Mahurangi, *Ibid.*, pp. 101-106.

—— 1884b. On the Igneous Rocks of the East Coast of Wellington, *Ibid.*, pp. 71-75.

—— 1884c. On the Geology of the Kawhia District, *Ibid.*, pp. 140-148.

—— 1887. On the Geology of East Auckland and the Northern District of Hawkes Bay, *Rep. Geol. Explor. during 1886-87*, pp. 182-219.

—— 1888. On the Geology of the Northern District of Auckland, *Rep. Geol. Explor. during 1887-88*, pp. 37-57.

Marshall, P., 1908. Geology of Centre and North of North Island, *Trans. N.Z. Inst.*, vol. 40, pp. 79-98.

—— 1916. The Younger Limestones of New Zealand, *Ibid.*, vol. 48, pp. 87-99.

—— 1916a. Relations between Cretaceous Rocks, *Ibid.*, vol. 48, pp. 100-119.

—— 1917. The Geology of the Central Kaipara, *Ibid.*, vol. 49, 433-450.

—— 1924. The "Hydraulic Limestones" of North Auckland, *Ibid.*, vol. 55, pp. 617-618.

—— 1926. The Upper Cretaceous Ammonites of New Zealand, *Ibid.*, vol. 56, pp. 129-210.

Mulgan, E. K., 1902. The Volcanic Grits and Ash Beds in the Waitemata Series, *Ibid.*, vol. 34, pp. 414-435.

Park, J., 1886. Waitemata, Eden and Manukau Counties, *Rep. Geol. Explor. during 1885*, pp. 147-163.

—— 1887. Kaipara and Wade District, Auckland, *Rep. Geol. Explor. during 1886-87*, pp. 219-229.

—— 1889. The Conformable Relations of Different Members of the Waitemata Series, *Trans. N.Z. Inst.*, vol. 21, pp. 391-399.

—— 1893. On the Occurrence of Granite and Gneissic Rocks in the King Country, *Ibid.*, vol. 25, pp. 353-362.

—— 1910. *The Geology of New Zealand.*

Smith, S. P., 1881. On Some Indications of Change in the Level of the Coast-line in the Northern Part of the North Island, *Trans. N.Z. Inst.*, vol. 13, pp. 398-410.

Sollas, W. J., and McKay, A., 1906. *The Rocks of the Cape Colville Peninsula*, vol. 2, Wellington.

Tertiary Molluscan Fauna of Chatton, Southland.

By J. MARWICK, M.A., D.Sc.

[*Abstract read, by permission of the Director of the N.Z. Geological Survey, before the Wellington Philosophical Society, 28th November, 1928; received by Editor, 29th November, 1928; issued separately, 25th March, 1929.*]

THE object of this paper is primarily a description of the molluscan fauna of Chatton, eight miles north of Gore, Southland. Field-occurrences and stratigraphical relations are not discussed as such a course would have entailed further delay of a paper promised long ago.

The material belongs to two collections. One was made as far back as 1913 by Mr. R. A. W. Sutherland, now of Wanganui, and was kindly donated by him to the Geological Survey about six years ago in the hope that it would be critically examined. Work has proceeded intermittently on the material as opportunity offered, and the present paper is largely a result of that work.

In 1925 the late Dr. J. Allan Thomson lent to the Geological Survey a large collection gathered by Mr. E. M. Christie, of Gore, who has since then added to his original material. My sincere thanks are due to these gentlemen for providing facilities to describe such an interesting molluscan fauna. The Dominion Museum specimens were prepared by Miss M. Mestayer with great care, and thus were preserved many fragile specimens which would otherwise have been lost.

To clear the ground for discussion of the affinities and age-equivalents of the Chatton fossils it is necessary to discuss Suter's record of 29 per cent. of Recent species. Suter's list (1921, p. 95) was prepared from Mr. Sutherland's collection, and most of the manuscript labels are preserved, so that practically all of the indentifications can be checked.

It will be seen from the comparative list given below that the results of the re-survey are very different from the original. Suter's conception of fossil species was vague and inconsistent, so that his groups are in general far too wide to be of practical significance. The palaeontological evidence cited by Dr. Marshall (1917, p. 460, p. 465) is therefore badly based, though the Oligocene age allotted to the Chatton beds by him is probably correct.

Accurate correlation of the Chatton sands with other fossiliferous deposits of New Zealand is difficult because of the very large proportion of new species. The assemblage of genera, however, agrees much more closely with that of middle Tertiary faunas (Ototaran to Awamoan) than with early Tertiary ones. This might be claimed to be the result of environment rather than time; but the complete absence of archaic or older Tertiary elements such as *Monalaria, Speightia,* Aporrhaidae, and Avellanidae, definitely rules out the

Bortonian and Tahuian stages. The Waiarekan is known only from a relatively small fauna which lived in a somewhat unusual environment, for the fossils occur in the fine tuffaceous calcareous matrix of a coarse igneous conglomerate. The presence of *Spirocolpus tophina* (Marw.) at both Lorne and Chatton is the only strong connecting link between the two faunas.

Although the generic constitution agrees well with the Awamoan, the consistent differences in related species demand a considerable lapse of time for their development. The absence of such characteristic Awamoan species as *Limopsis zealandica* Hutton, *Turritella* (*Maoricolpus*) *cavershamensis* Harris, *Nassarius socialis* (Hutton), *Comitas fusiformis* (Hutton) is also noteworthy.

Dr. Finlay (1924, p. 534) has already shown from the rich faunas secured by him at Clifden, Southland, that the period of time between the Waiarekan and Awamoan stages, represented by Thomson's Ototaran and Hutchinsonian, was of relatively long duration. It is to the earlier part of this period, i.e., to the Ototaran, that the Clifden fauna probably belongs. Finlay (1924, p. 535) has also correctly drawn attention to the close resemblance of the Chatton fauna to that of the Wharekuri greensand. Many of the common species at both localities are strikingly similar, but yet show important differences of detail. These are differences which may be due to environment, although the time factor has not yet been disposed of.

Revised list of Chatton Mollusca.

(Suter's identifications on the right.)

Nucula tersior n. sp.	*Nucula hartvigiana*
Nucula vestigia n. sp.	*Nucula* n. sp.
Nuculana probellula n. sp.	
Cucullaea worthingtoni Hutt.	
Glycymeris thomsoni n. sp.	*Glycymeris subglobosa.*
Limopsis parma n. sp.	
Anomia n. sp.	
Ostrea wollastoni Fin.	
Cyclopecten compitum n. sp.	
Spissatella poroleda Fin.	*Crassatellites obesus.*
Chattonia animula n. gen. et sp.	
Venericardia christiei n. sp.	*V. ponderosa.*
Venericardia pseutella n. sp.	*V. pseutes.*
Venericardia caelebs n. sp.	*V. difficilis.*
Venericardia prolutea n. sp.	
Eulopia staminifera n. sp.	
Gonimyrtea bucculenta n. sp.	
Maoritellina imbellica n. sp.	*Erycina?*
Solecurtus chattonensis Fin.	
Gari n. sp.	*Psammobia* n. sp.
**Scalpomactra* cf. *scalpellum* (Reeve).	
Zenatia sp.	
Paradione cf. *parki* Marw.	*Macrocallista multistriata.*

Dosinia sodalis n. sp.	
Dosinia imperiosa n. sp.	
Kuia cf. *vellicata* (Hutt.) juvenile.	
Turia chattonensis Marw.	
Bassina speighti (Sut.)	
Corbula canaliculata Hutt.	
Corbula pumila Hutt.	*Corbula pumila.*
**Nemocardium* aff. *pulchellum* (Reeve).	
Pholadidea increnata n. sp.	
Myadora delta n. sp.	
Antisolarium vixincisum n. sp	*Solariella* n. sp.
Elachorbis duplicarina n. sp.	*Circulus* n. sp.
Spirocolpus tophina (Marw.)	
Zeacolpus chattonensis n. sp	{ *Turritella cavershamensis.* { *Turritella concava.*
Mesalia striolata (Hutt.)	*Mesalia striolata.*
Struthiolaria subspinosa Marw.	
Zefallacia chattonensis n. sp	*Nerinea* n. sp.
Pyrazus sutherlandi n. sp.	*Batillaria pomahakensis.*
	Crepidula costata.
Maoricrypta salebrosa n. sp.	*Crepidula gregaria* sub sp. nov.
	Sinum fornicatum.
Sigapatella mapalia n. sp.	*Calyptraea tenuis*
Cochlis notocenica (Fin.)	*Natica zelandica.*
Cochlis consortis (Fin.)	
Polinices huttoni v. Iher.	
Polinices chattonensis (Marw.)	
Polinices cf. *lobatus* (Marw.)	
Polinices incertus (Marw.)	
Polinices blaesus n. sp.	
Magnatica sutherlandi (Marw.)	
Cirsotrema cf. *lyratum* (Zitt.) fragment.	*Epitonium lyratum.*
Notacirsa n. sp.	*Turbonilla prisca.*
Odostomia alexanderi n. sp.	*Odostomia bembix.*
Syrnola wallacei n. sp.	
Syrnola aclyformis n. sp.	
Turbonilla chattonensis n. sp.	*Turbonilla zealandica.*
Proximitra incisula n. sp.	
Cominella (*Cominista*) *chattonensis* (Fin.)	*Cominella* n. sp.
Austrofusus precursor Fin.	*Siphonalia nodosa.*
Xymenella inambitiosa n. sp.	
Trigonostoma christiei Fin.	
Baryspira robusta (Marw.)	
Baryspira electa n. sp.	*Ancilla papillata.*
Erato marshalli n. sp.	
Metamelon inermis (Fin.)	*Mitra* n. sp.
Austrodrillia cinctuta n. sp.	
Austrotoma inaequabilis n. sp.	

Austrotoma toreuma n. sp.	
Phenatoma (*Cryptomella*) *crassispiralis* n. sp.	
Acuminia transitorsa n. sp.	
Acuminia suteri n. sp.	*Terebra* n. sp.
Acteon chattonensis n. sp.	*Acteon* n. sp.
Ringicula castigata n. sp.	*Ringicula uniplicata.*
Bullinella enysi (Hutt.)	
Dentalium solidum Hutt.	*Dentalium solidum.*
Rhyssoplax allan-thomsoni Mestayer.	

The following species listed by Suter are not included above, for the reasons given in each case: *Cardium* sp. fragments; *Corbula zelandica* much too worn for identification but belonging to same group; *Cuna* sp., *Cyamiomactra* sp., both young Venerids; *Marginella conica,* specimen smashed; *Modiolus australis,* not seen; *Odostomia sherriffi,* apex of young shell, indeterminable; *Pecten hutchinsoni* not seen; *Siphonalia valedicta* indeterminable fragment; *Trophon* sp.? fragments of Turrid and another shell not generically located.

The Recent species *Scalpomactra scalpellum* is doubtful. More specimens are required to show whether they are to be separated as a distinct species or not.

Genus NUCULA Lamarck, 1799.

Type: *Arca nucleus* Linné.

Nucula tersior n. sp. (Figs. 4, 6.)

Shell small, fragile, ovate; beaks prominent, about posterior sixth. Posterior end regularly convex; anterior end narrowly rounded, dorsal margin descending rapidly in moderate curve. *Lunule* not defined apart from increased curvature of disc. *Escutcheon* slightly bulging the outline, its outer margin defined by weak depression. *Sculpture* of low, bevelled, concentric ridges becoming obsolete over central part of disc which is smooth and shining; traces of fine radial threads appear in some of the interspaces. *Hinge* with about eleven anterior and five posterior teeth. Resilifer but little projecting. *Valve-margins* finely, regularly crenulated.

Holotype in collection of N.Z. Geological Survey.

Height, 2.5 mm.; length, 2.6 mm.

Suter identified this shell with *N. hartvigiana* Pfr. to which it is probably ancestral. The differences in the fossil, however, easily warrant specific recognition, e.g., much smaller size, more regularly rounded posterior end, fewer hinge teeth, broader beaks.

Nucula vestigia n. sp. (Figs. 1, 3.)

Shell small, ovate; beaks high, about posterior fourth. *Lunule* not well defined; *escutcheon* broad, bounded by low ridge. *Sculpture* of fine radial riblets, crossed by irregular, interlocking ridges in the spaces between which are the radials. Towards margin fairly regular, sharp, concentric ridges occur. *Hinge* strong, with about 11 anterior and 7 posterior teeth. *Internal margin* finely, regularly crenulated.

Holotype in collection of N.Z. Geological Survey.

Height, 3.5 mm.; length, 3.5 mm.; inflation, 1.2 mm.

The irregular criss-cross sculpture resembles that of *N. sagittata* Suter on which it appears only on the lunule.

Genus NUCULANA Link, 1807.

Type: *Arca rostrata* Linné.

Nuculana probellula n. sp. (Figs. 2, 5.)

This shell is, in all probability, on the direct ancestral line of *N. bellula* (A. Adams) from which it differs in being less produced posteriorly. Further, the hinge is heavier and the escutcheon is more concave and has the concentric grooves reaching about half way across it. Young specimens are relatively more attenuated and approach but do not coincide with *N. bellula.* The hinge, however, is always rather longer and deeper. The sculpture of both species is of practically the same gauge, namely 6 or 7 grooves per mm. From *N. belluloides* Allan the Chatton shell is distinguished by the narrower posterior and more concave escutcheon.

Holotype in Dominion Museum.

Height, 4 mm.; length, 7 mm.; inflation (1 valve), 1.8 mm.

Genus CUCULLAEA Lamarck, 1801.

Type: *Cucullaea auriculifera* Lamk.

Cucullaea worthingtoni Hutton.

1873. *Cucullaea worthingtoni* Hutton, *Cat. Tert. Moll.*, p. 27.
1873. *Cucullaea attenuata* Hutton, *Cat. Tert. Moll.*, p. 28.
1914. *Cucullaea worthingtoni* Hutton: Suter, *N.Z. Geol. Surv. Pal. Bull.* 2, p. 37, pl. 6, Figs. 1, a, b,
1915. *Cucullaea attenuata* Hutton: Suter, *N.Z. Geol. Surv. Pal. Bull.* 3, p. 49, pl. 2, Figs. 1, a, b.

Young shells only, and so of uncertain specific position. They resemble Suter's figure (1915, p. 48, pl. 6, fig. 20) of *Macrodon* (*Cucullaria*) *australis* Hutton, which Suter rightly classed as *Cucullaea,* but which he accepted as an adult, whereas in all probability it is a young shell of *C. worthingtoni* or a closely-related species. In any revision of New Zealand Tertiary species *Cucullaea dalli colona* v. Ihering (1907, p. 93) should not be overlooked. At present it is impossible to recognize this species as no locality and no figure were given by von Ihering.

Genus GLYCYMERIS Da Costa, 1778.

Type: *Arca glycymeris* Linné.

Glycymeris thomsoni n. sp. (Figs. 18, 21.)

Shell large and strong, oval, inflated. Anterior margin almost regularly convex, dorsal part slightly drawn up. Posterior margin subangled near middle by strong ridge running from umbo. *Sculpture* of about fifty low almost flat radial ribs with very narrow interspaces, ribs of posterior noticeably narrower, fairly wide space near both anterior and posterior dorsal margins free of these radials.

Whole surface with traces of radial threads, five or six per rib. *Ligamental area* broad, about half length of shell, with five weak, fairly close, incised chevrons. *Hinge-teeth,* about four posterior and four anterior fully developed, rest invaded by ligamental area, and almost obliterated. *Valve-margins* crenulated.

Holotype in Dominion Museum.

Height, 81 mm.; length, 87 mm.; inflation (1 valve), 31 mm.

Easily distinguished from *G. subglobosa* by the shape.

Genus LIMOPSIS Sassi, 1827.

Type: *Arca aurita* Brocchi.

Limopsis parma n. sp. (Figs. 14, 15.)

Shell of moderate size, ovate; beaks not prominent. Outline somewhat variable. Up to about 15 cm. diameter, most are subcircular; from then onwards some grow much more along posterio-ventral margin and so become markedly oblique, others keep more to the youthful outline though there is always a certain amount of obliquity. Some specimens show strong ventral growth and so become considerably elongated. Dorsal margins characteristically short and inclined. *Surface* with somewhat irregular, low, concentric ridges which are very weak on central part of disc, so shell has shining surface across which ridges cross as lines. Weak radial grooves are present, more strongly developed distally. Where they cross the concentric ridges, crenulations are formed which are fairly strong on posterior area. *Cardinal area* between one-half and two-fifths length of shell, traversed by rather broadly triangular chondrophore which has apical angle of about 100°. *Hinge* broad, teeth relatively long, about 10 posterior and 10 anterior. *Adductor impressions* of moderate size, the anterior one not at all concealed by hinge plate. *Valve-margins* bevelled, smooth.

Holotype in Dominion Museum.

Height, 25 mm.; length, 26 mm.

This species is related to *L. zitteli* but distinguished from it by smaller chondrophore, more circular adult shell, and rather stronger ornamentation. It is close to *L. campa* Allan from Waihao greensands, but has a smaller chrondrophore.

Genus OSTREA Linné, 1758.

Type: *Ostrea edulis* Linné.

Subgenus GIGANTOSTREA Sacco, 1897.

Type: *Ostrea gigantica* Solander.

Ostrea (Gigantostrea) wollastoni Finlay. (Figs. 16, 17.)

1873. *Ostrea incurva* Hutton, *Cat. Tert. Moll.*, p. 35 (not of Nilsson).

1915. *Ostrea incurva* Hutton: Suter *N.Z. Geol. Surv. Pal. Bull.* No. 3, p. 53, pl. 3, fig. 1, pl. 7, figs. 2a, b.

1927. *Ostrea wollastoni* Finlay, *Trans. N.Z. Inst.*, vol. 57, p. 528.

A giant specimen was collected by Mr. Christie. It measures 165 mm. long and 183 mm. high. The depth of the left valve is

110 mm., of this the body cavity occupies about 45 mm., so the shell substance is 65 mm. thick. The right valve is almost flat and has a maximum thickness of 49 mm. The total weight is 9 lbs. 7 ozs. The external surface is not well preserved, but radial ribs are absent. The outline is more circular than that of the type, and the ligamental area relatively larger.

Perhaps *O. suteri* v. Ihering (1907, p. 94) would be a better classification. This species was introduced only incidentally; but the locality, Westport, was given, and also characters to distinguish it from *O. hatcheri* Ortmann and *O. patagonica* d'Orb.

Genus CYCLOPECTEN Verrill, 1897.

Type: *Cyclopecten postulosus* Verrill.

Cyclopecten compitum n. sp. (Fig. 8.)

Shell minute, prodissoconch smooth, sharply defined. *Left valve* with ears of moderate size not sharply defined from disc. *Surface* smooth in young stages, but later with many fine, close radial threads, not persistent but tending to zonal arrangement. Towards margin appear about 17 rounded, strong radial ribs with much wider interspaces. The ribs bear strong spaced scales and tend to be knotty. Concentric growth-lines well marked, some, especially on posterior, projecting as jagged edges.

Holotype in collection of N.Z. Geological Survey.

Height, 1.6 mm.; length, 1.4 mm.

Easily distinguished from the Recent species by the discrepancy in sculpture. In a recent revision of the New Zealand Pectinidae (Marwick, 1928, p. 456) the writer unfortunately overlooked a *lapsus calami* so that *Cyclochlamys* appears instead of *Cyclopecten*. Thanks are due to Dr. H. J. Finlay for noticing this mistake.

Genus CHATTONIA n. gen.

Type: *Chattonia animula* Marwick.

Shell small, hatchet-shaped, strong; beaks prominent, at anterior third or fourth; posterior end broadly truncated, bounded below by low ridge. *Sculpture* of regular concentric grooves. Hinge of moderate width. *Left hinge* with two narrow, divergent, anterior cardinal teeth, anterior one much the stronger and well separated from raised lunular border. Behind these cardinals is a triangular ligamental space bounded posteriorly by long curved posterior lateral which extends two-thirds length of dorsal margin from which it is separated by a well-defined groove. *Right hinge* with long straight anterior lateral confluent with lunular margin above; cardinal tooth strong, posterior lateral long, curved. *Internal margins* smooth.

Chattonia animula n. sp. (Figs. 10, 11, 12.)

Holotype in Dominion Museum.

Height, 4.5 mm.; length, 5.3 mm.; inflation (1 valve), 1.25 mm.

For description see generic diagnosis above. The specimens show considerable variation in shape, size, and coarseness of sculpture, so that further collecting may necessitate specific subdivision. The

largest specimen is nearly 9 mm. long. The elements of the hinge are the same as those of *Crassatellites*, but this does not necessarily demand inclusion in that genus, for the crassatelloid hinge is an extremely conservative one. The small size, the curved dorsal margin, the shape of the lateral teeth, and the very narrow ligamental scar on the hinge deserve full generic recognition.

Genus VENERICARDIA Lamarck, 1801.

Type: *Venericardia imbricata* Lamk.

Venericardia christiei n. sp. (Figs. 23, 28, 30.)

Shell large, heavy; beaks prominent, near anterior end. *Lunule* deeply sunk, convex in youth, but sloping inwards as growth proceeds, bounded by an incised line. *Escutcheon* shallow, not well defined. *Sculpture* of about 24 strong, rounded radial ribs, with well-marked interstices of about same width. Close, regular growth-striae cover the shell but are stronger in interstices, also ribs have indications of obscure nodes at intervals. In spite of these irregularities the surface has a smooth shining appearance. *Hinge* deep and strong, teeth well grooved; *left valve* with the inward sloping lunule only slightly invading anterior cardinal tooth with which it forms an angle of 30°. *Right valve* with a broad median cardinal well separated from thin anterior cardinal which in turn is distant from lunular margin; posterior cardinal forming rudimentary ridge on nymph.

Holotype in Dominion Museum.

Height, 50 mm.; length, 50 mm.; inflation (1 valve), 19 mm.

This species is related to *V. awamoaensis* Harris (= *V. pseutes* Suter) but it can readily be recognized by the higher, narrower ribs and wider interspaces. The hinge-teeth, and lunule of *V. christiei* are not so oblique as those of *V. awamoaensis*, so that the space between the lunular border and the anterior cardinal is much wider. Also *V. awamoaensis* is usually less oblique in shape, the umbos being lower and not so far forward.

Venericardia pseutella n. sp. (Figs. 29, 31.)

Shell of moderate size, beaks prominent, about anterior fifth. *Lunule* small, concave, sloping forward below, scarcely invading anterior cardinal tooth above. *Escutcheon* not developed. *Sculpture* of 28 very low, smooth, rounded radials with linear interstices, ribs of posterior area narrower than others. *Left hinge* with two strong cardinals, anterior one forming with lunule a triangular space; posterior one arched.

Holotype in Dominion Museum.

Height, 21.5 mm.; length, 22.5 mm.

Only two incomplete left valves were collected. They closely resemble *V. awamoaensis* Harris but differ in having the lunule sloping forward instead of backward, almost parallel to anterior cardinal, in this respect being like *V. christiei*. They are readily distinguished from this shell however by the much weaker and more numerous radials.

Venericardia caelebs n. sp. (Figs. 22, 24.)

Shell of moderate size, umbo fairly prominent, at anterior fourth. *Lunule* convex, cordate, sloping forward. *Escutcheon* not developed. *Sculpture* of 29 high, rounded, radial ribs with interspaces about same width; anterior two ribs and posterior one extremely weak. Ribs on anterior part of disc with regular transverse ridges, but those on posterior part almost smooth, except the fourth from last which has prominent spaced spines. Ribs on posterior area considerably weaker than those of central part of disc. *Hinge* of moderate width; *left valve* with anterior cardinal strong, triangular, well separated from arched lunular border; posterior cardinal long, arched, of moderate strength, parallel to ligamental nymph. *Right* median cardinal evidently very broad.

Holotype in collection of N.Z. Geological Survey.

Height, 27 mm.; length, 30 mm.; inflation (1 valve), 10 mm.

Differs from the Recent species, *V. difficilis* (Desh.), in having rather more ribs, which, moreover, are almost smooth over a great part of the shell. The hinge is of the same general type as that of *V. purpurata* (Desh.) but the left posterior cardinal is longer and further away from the anterior one, so that the right median cardinal must be considerably broader. Also the adductor-scars of the Recent shells, especially the anterior one, are much larger than in the fossil. A single left valve has been collected.

Subgenus PLEUROMERIS Conrad, 1867.

Type: *Cardita tridentata* Say.

Venericardia (Pleuromeris) prolutea n. sp. (Figs. 25, 26, 27.)

Shell small, subequilateral; beaks almost central, moderately high. *Lunule* flattened, large, lanceolate, smooth, not invading hinge-area. *Escutcheon* long and narrow, smooth, not depressed. *Sculpture* of sixteen high, strongly and regularly-beaded radial ribs with equal interstices. *Left hinge* with two strong cardinals forming angle of about 77°; anterior cardinal well separated from lunular margin. Anterior and posterior laterals present. *Right hinge* with strong triangular median cardinal; anterior and posterior cardinals rudimentary. Anterior and posterior laterals present.

Holotype in Dominion Museum.

Height, 6 mm.; length, 6 mm.; inflation, 2.25 mm.

Differs from the Recent *V. lutea* Hutt. in having more ribs, and in the beaks being almost median, thus making the shell subequilateral. Further, the hinge-line is narrower in the fossil.

Genus EULOPIA Dall, 1901.

Type: *Lucina sagrinata* Dall.

Subgenus NOTOMYRTEA Iredale, 1924.

Type: *Myrtea botanica* Hedley.

Eulopia (Notomyrtea) staminifera n. sp. (Figs. 35, 36, 37.)

Shell small, laterally compressed, beaks central, prominent. *Lunule* and *escutcheon* well defined, long, narrow, smooth, wider in

left valve. *Sculpture* of rather sharp, concentric, irregularly-spaced lamellae, about five per millimetre, with wide, flat interspaces which are occupied by dense vermiculate radial threads. *Left hinge* with two curved triangular cardinals; margins of lunule and escutcheon raised distally to function as lateral teeth; lunular one with low ridge below, posterior one with trace of a groove. *Right hinge* with curved triangular cardinal and a strong anterior also a strong posterior lateral, each of which forms with raised margin a deep socket to receive lateral tooth of left valve. *Adductor* impressions not strongly marked but apparently triangular, anterior one slightly elongated.

Holotype in Dominion Museum.

Height, 5.6 mm.; length, 6.3 mm.; inflation (1 valve), 1.2 mm.

E. staminifera differs from *E. papatikiensis* in shape, the beaks being considerably higher, so that the angle between dorsal and lunular margins is less. Also the left anterior lateral of *E. papatikiensis* is well developed and distant from the lunular margin.

When Iredale (1924, p. 206) introduced *Notomyrtea* for Australian shells with fine radials in the concentric interspaces, he did not discuss *Eulopia* proposed by Dall. for American shells with the same feature. Recently Finlay (1926, p. 461) transferred *Myrtea* (*Eulopia*) *papatikiensis* Marwick to *Notomyrtea,* also without discussing *Eulopia.* The only outstanding difference from the New Zealand shells shown by *E. sagrinata* is the considerably greater inflation. The general shape, sculpture, and hinge are so alike that it would be well to associate the groups generically. The radial ornament is a very persistent character and marks clearly defined groups of extended range both geographically and stratigraphically; it therefore justifies generic recognition of *Eulopia.*

Genus GONIMYRTEA n. gen.

Type: *Loripes concinna* Hutton.

Shell subtriangular because of obscure ridge running from umbo to middle of anterior margin, and another to posterior margin which is angled below middle. *Lunule* broadly concave, not invading hinge area, and not interfering with development of teeth. *Lateral teeth* of right valve extremely weak, left valve with no true laterals, the lunular margin being slightly raised to function as one. Anterior adductor impression long and narrow.

The poor development of lateral teeth, the long anterior adductor, and the shape of the shell, readily distinguish this genus from *Notomyrtea.*

Finlay (1926, p. 461) has already noted the possibility of this distinction.

Gonimyrtea bucculenta n. sp. (Figs. 32, 33, 34.)

Shell subcircular, beaks slightly in front of middle, not prominent. *Lunule* lanceolate, well sunk, smooth. *Escutcheon* absent. A weak ridge runs to anterior margin from umbo forming weak anterior wing. *Sculpture* of narrow, relatively high, very regular concentric ridges, 6 per millimetre, with much wider flat interspaces. *Left*

hinge with two small cardinals diverging from under umbo, lunular margin raised to function as a lateral. *Right hinge* with single triangular cardinal and small anterior tubercle. *Anterior* muscle-impression long and narrow, posterior triangular. *Interior* of shell striated above pallial line. *Valve-margins* smooth.

Holotype in collection of N.Z. Geological Survey.

Height, 6 mm.; length, 6.5 mm.; inflation (1 valve), 2 mm.

Distinguished from the Recent and Pliocene *P. concinna* by the more orbicular shape, less prominent anterior and posterior marginal angulations and well spaced ribbing.

Genus MAORITELLINA Finlay, 1926.

Type: *Tellina charlottae* E. A. Smith.

Maoritellina imbellica n. sp. (Figs. 7, 9.)

Shell small, fragile, ovate. Beaks slightly behind middle line. Anterior end rather narrowly convex, the dorsal margin slightly curved descending fairly rapidly. Posterior end subangled, bent slightly to right. *Sculpture* of low, sharp, concentric threads, distantly and regularly spaced, but developed only on posterior half of disc. A few microscopic radials closely grouped are on distal posterior part of obscure fold running from umbo to posterior angle. *Right hinge* with two cardinals, anterior narrow, posterior triangular, bifid, laterals well developed, posterior slightly closer to umbo than anterior but not overlapping ligament. *Pallial sinus* not visible. *Valve-margins* smooth.

Holotype in collection of N.Z. Geological Survey.

Height, 4.5 mm.; length, 6 mm.

Genus DOSINIA Scopoli, 1777.

Type: *Artemis africana* Hanley.

Subgenus RAINA Marwick, 1927.

Type: *Dosinia bensoni* Marwick.

Dosinia (Raina) sodalis n. sp. (Figs. 38, 39, 40.)

Shell of moderate size, strong, subcircular. *Lunule* long and narrow, bounded by deeply-incised line. *Escutcheon* long and deep, bounded by sharp ridge especially in left valve. *Sculpture* of high, narrow, erect, regular, well-spaced concentric ridges, about 8 per centimeter, becoming obliquely lamellar on posterior slightly concave area. *Left hinge* with strong curved posterior cardinal; strong rugose median, and lamellar anterior cardinal, space between last two with deep pit along anterior side. Anterior lateral broad, low, very strongly ridged. *Right hinge* with fairly strong, bifid, posterior cardinal, stout, rugose median, and short, thin and low anterior cardinal. Space between first two with shallow excavation along posterior side. Anterior pit with low smooth lateral above, strongly grooved below.

Holotype in Dominion Museum.

Height, 52 mm.; length, 52 mm.; inflation (1 valve), 14 mm.

Easily distinguished by the sculpture, concentrated hinge, and very deep escutcheon.

Dosinia (Raina) imperiosa n. sp. (Figs. 41, 42.)

Shell large and heavy. *Lunule* large and broad, bounded by incised line. *Escutcheon* deep, not commencing until shell is about 20 mm. diameter, crossed by fairly strong continuations of the concentric sculpture. *Sculpture* of strong, bevelled, polished, concentric ridges with slightly narrower interspaces, the ridges becoming narrower and oblique on posterior area. *Right hinge* with strong, bifid posterior cardinal; strong, triangular, rugose median, and short, strong, high anterior cardinal. Anterior pit deep, with weak, smooth lateral above, strongly rugose below. *Nymph* with strongly raised anterior margin along groove for left posterior cardinal. *Pallial sinus* reaching to near middle of shell.

Holotype in Dominion Museum.

Height (estimated), 60 mm.; length (estimated), 60 mm.; inflation (1 valve), 20 mm.

Distinguished from *D. sodalis* by greater inflation and broader lunule, escutcheon starting at much later stage, broader right posterior and anterior cardinals, and sculpture.

Genus PHOLADIDEA Goodall, 1819.

Type: *Pholadidea loscombiana* Goodall.

Pholadidea increnata n. sp. (Fig. 13.)

Shell somewhat small, elongate; beaks at anterior fourth. Anterior dorsal margin strongly reflexed. *Sculpture*: an oblique groove stretching from umbo backwards to middle of ventral margin. Behind this the surface bears low, broad, regular concentric folds with in addition one or two irregularly placed growth-lamellae. In front of the groove are strong, regular, well-spaced concentric lamellae which show only faint traces of marginal crenation. No sign of anterior lower callus-plates.

Holotype in Dominion Museum.

Height, 10 mm.; length, 18.5; inflation (1 valve), 4 mm.

Differs somewhat from the Recent *P. tridens* Gray in broader posterior and presence of well-spaced, scarcely crenate lamellae on the anterior area. Also the anterior ventral margin ascends, in a gentle convexity from the oblique groove and not in a broad sinus.

Genus MYADORA Gray, 1840.

.Type: *Pandora brevis* Sowerby.

Myadora delta n. sp. (Figs. 19, 20.)

Shell rather small, subtriangular; beaks slightly behind middle; apical angle about 100°. *Left valve* concave, with relatively strong posterior twist. Anterior dorsal margin straight, descending at about 45° to narrowly rounded anterior margin. Posterior dorsal margin flatly sigmoid, merging into obliquely truncated posterior margin. Ventral margin widely arcuate. *Lunule* and *escutcheon* narrow, flat, extending full length of dorsal margins. *Sculpture* of low, broad, concentric ridges, obsolete over most of disc, but strong along anterior dorsal margin. *Lithodesma* narrowly triangular. Anterior and posterior margins of shell raised and grooved along whole length. *Adductor-scars* noticeably distant from umbo and near ventral

margin. *Pallial sinus* broad and shallow, a radial groove extending from front of it towards umbo. *Valve-margins* smoothly rounded.

Holotype in Dominion Museum.

Height, 7.5 mm.; length, 9.5 mm.

Paratype, 7.3 x 9 mm.

This shell resembles *M. novaezelandiae* Smith in shape but the apical angle is considerably greater.

Genus ANTISOLARIUM Finlay, 1926.

Type: *Solarium egenum* Gould.

Antisolarium vixincisum n. sp. (Fig. 44.)

Shell small, fragile, conical, perforate. *Whorls* six, moderately convex, increasing regularly; body-whorl angled at periphery in young but only subangled in adult; base convex. *Protoconch* conic, with small nucleus, number of whorls uncertain as no division between it and brephic stage is to be seen. *Suture* impressed. *Sculpture* of indistinct spiral ridges somewhat irregularly spaced, about 6 on body-whorl above periphery, which is marked by a fairly strong thread. Some species have only a spiral below the suture and one on periphery. On base, the spirals are extremely weak, but a moderately strong one is sometimes present close to periphery. Faint but regular growth-lines cross obliquely backwards from suture to periphery, and are noticeably arcuate between periphery and umbilicus. *Umbilicus* open, about ¼ diameter of base, bounded by strong, moniliform thread which has a smoother, weak spiral above and sometimes one below it. *Aperture* subrhombic. *Outer lip* retreating from suture at about 45°, broadly sinused on base. *Inner lip* broadly concave above where it sweeps round to parietal wall, sometimes lightly channelled below at ends of umbilical spirals.

Holotype in Dominion Museum.

Height, 4 mm.; diameter, 4 mm.

On several specimens traces of the colour-ornament of brown axial bars and splotches still remain.

No very closely-related species has yet been described, the absence at any stage of the biangulate spire-whorl being peculiar. Many of the specimens are quite smooth, but this may be the result of decortication, as the outer shell-layer is inclined to become powdery.

Genus ELACHORBIS Iredale, 1915.

Type: *Cyclostrema tatei* Angas.

Elachorbis duplicarina n. sp. (Figs. 43, 45, 46.)

Shell minute, almost planispiral. *Whorls* four, convex on spire, body-whorl bicarinate. *Protoconch* of 2¾ smooth whorls with first two showing but little increase in diameter. *Sculpture* of four smooth spiral cords on body-whorl above periphery. Interstices about equal to cords. Upper keel, marking periphery, high and sharp; lower keel not so strong but still well defined. Space between keels with 3 rather close spirals; base with about 7 spaced threads. Growth-lines extremely fine. *Aperture* subcircular, with blunt angles at the keels. *Outer lip* thin, oblique. *Umbilicus* wide, open, with a strong

spiral which causes an embayment in the inner lip.

Holotype in collection of N.Z. Geological Survey.

Height, .8 mm.; diameter, 2 mm.

The classification under *Elachorbis* is only provisional, for the two strong keels are not present in that genus. The shell figured by Cossman [1918, pl. 2, figs. 51, 52, 53] as *Tornus* (*Adeorbis*) *miobicarinatus* Sacco, from the Miocene of France, has a strong resemblance in general characters.

Genus SPIROCOLPUS Finlay, 1926.

Type: *Turritella waihaoensis* Marwick.

Spirocolpus tophina (Marwick).

1926. *Turritella tophina* Marwick, *Trans. N.Z. Inst.*, vol. 56, p. 313, pl. 72, fig. 21.

The adult specimens available are all somewhat eroded, but they seem to agree closely with the Waiarekan species. Many well-preserved apices occur, showing the strongly monilform character of the spirals on early whorls.

Genus ZEACOLPUS Finlay, 1926.

Type: *Turritella carlottae* Hutton.

Zeacolpus chattonensis n. sp. (Figs. 47, 49.)

Shell of moderate size, apical angle about 20°. *Protoconch* of about two smooth whorls. *Sculpture* commences with two smooth spirals on first post embryonic whorl, upper spiral stronger and giving whorl strong angulation, on second whorl a weak thread appears above first two; for first three post-embryonic whorls or so, upper of the two primary spirals is stronger, but about fourth whorl the lower equals it and on fifth forms prominent keel and upper primary degenerates to fine thread. Meanwhile, fine spiral threads have been appearing from about second whorl, so whole surface is closely spiralled. Strongly-keeled condition holds for three or four whorls during which upper part of each whorl has gradually been rising above suture, forming a cingulum with two strong threads and several weak ones. One of these strong threads is probably continuation of that commencing on second whorl. The whorls which are now about 4 mm. diameter retain much the same character until about 12 mm. diameter; that is, the whorl is girdled by median concavity bounded below by single strong spiral, concave under-side of which retreats rapidly to constricted suture. Upper side of median concavity bounded by weaker spiral with another still weaker on each side, the three set on a cingulum of the whorl which retreats to suture in a convexity. Whole surface with fine spiral threads, some of which become relatively prominent. The specimen shown in figure 47 appears to be a gerontic development, the whorl is almost flat, but the suture is still well constricted. *Aperture* subquadrate, outer lip with a fairly deep sinus, the broadly rounded apex of which is slightly below mid whorl and posterior side advancing further than anterior.

Holotype in Dominion Museum.
Height (estimated), 45 mm.; diameter, 12 mm.
Paratype (Fig. 47), estimated 80 x 20 mm.

Genus ZEFALLACIA Finlay, 1926.

Type: *Fastigiella australis* Suter.

Zefallacia chattonensis n. sp. (Fig. 63.)

Shell large, turriculate, increasing regularly. *Whorls* cylindrical, suture deeply incised, body-whorl contracted quickly to short twisted canal not notched at base. *Sculpture* of low, regular, arcuate growth-ridges. Body-whorl with a few weak spirals just below suture-line. *Aperture* ovate, produced below into twisted canal about half length of aperture. *Outer lip* retreating from suture in broad shallow sinus. *Columella* with strong fold which is sharp and median in youth, but rounded and more anterior at maturity. *Inner lip* of adult with broadly expanded, projecting callus-plate.

Holotype in Dominion Museum.

Height (estimated), 70 mm.; diameter, 20 mm.

As noted by Finlay (1926, p. 384) this is the shell identified by Suter (1921, p. 95) as the Mesozoic *Nerinea* Defrance. Although the New Zealand shell certainly resembles *Nerinea* it does not belong to that family but to the Cerithiidae as placed by Finlay. This is shown by the single fold on the columella, complete absence of folds on the outer lip or parietal wall, and by the twisted canal. From *Z. australis* (Suter) the new species differs in being very much larger and in having regularly-increasing whorls. Whether adult *Z. australis* has an expanded inner lip is not known.

Genus PYRAZUS Montfort, 1810.

Type: *Strombus palustris* Linné.

Pyrazus sutherlandi n. sp. (Fig. 48.)

Shell large, solid, outline almost straight. *Whorls,* about 12 remaining, with shoulder slightly indicated by axials. *Suture* impressed, undulating. *Sculpture* of about eleven axial ribs per whorl. Ribs are broadly rounded and slightly nodulous being weaker across shoulder but extend from suture to suture and die out on base. Interspaces slightly wider than ribs. Whole surface with fine spiral threads, showing best in interstices. Last quarter whorl has been repaired after a break, and on it spirals are much stronger; six, especially, develop into rugose cords more prominent on ribs than in interspaces. *Outer lip* broken away. *Columella* twisted, apparently produced along short canal. *Inner lip* with fairly thick callus adhering to base of shell.

Holotype in collection of N.Z. Geological Survey.

Height, 100 mm.; diameter, 35 mm.

As the aperture is incomplete it is impossible to be sure about the generic affinities of this shell. Nothing closely related to it has so far been described from New Zealand; but judging from the figure *Cerithium pritchardi* Harris (1897, p. 226, pl. 7, fig. 3) belongs to the same group. Harris remarked on the resemblance of his species to *C. semicostatum* Deshayes (European Eocene) which is a *Vulgocerithium* Cossmann.

Genus MAORICRYPTA Finlay, 1926.

Type: *Crepidula costata* Sowerby.

Maoricrypta salebrosa n. sp. (Figs. 50, 51.)

Shell of moderate size, strongly convex, relatively high and narrow. Beaks strongly incurved, twisted well to the side and separated from the apertural margin by wide space covered with growth-lines. *Sculpture* of about 12 to 16 rounded, irregular, gnarled, spiral ridges with equal or wider interstices. These ridges generally stronger along crest of shell and narrower on outer or left side than on inner or right side. Growth-lines irregular. *Septum* extending about halfway along shell, a little further on left than right; anterior margin gently concave, with very shallow sinus in middle.

Holotype in Dominion Museum.

Height, 17 mm.; length, 40 mm.; width, 23 mm.

The sinuosity of the septal margin is rather better marked in this species than in the others of the group, i.e., *M. costata* Sowerby, *M. wilckensi* Finlay, etc., and is very different from that of the type of *Crepidula, C. fornicata* L. In *Crepidula* the septal margin follows a shallow sigmoid curve, in *Maoricrypta* it is gently concave with a shallow median sinus.

Genus SIGAPATELLA Lesson, 1830.

Type: *Calyptraea* (*Sigapatella*) *novae-zelandiae* Lesson.

Sigapatella mapalia n. sp. (Figs. 58, 59.)

Shell somewhat small, spire excentric. *Protoconch* of about two smooth whorls, conspicuously tilted and with nucleus slightly involved by second whorl. *Post embryonic* whorls two, strongly convex except for about one quarter turn of brephic stage where the whorl is much less convex. *Sculpture,* inconspicuous; concentric growth-lines fairly well marked on some specimens, a few with numerous weak spiral cords with interspaces of same width. Suture well defined on later part because of convexity of whorls, but obscure on early part. Basal plate with obliquely penetrating umbilicus.

Holotype in Dominion Museum.

Height, 5 mm.; diameter, 8 mm.

Resembles *S. novae-zelandiae* in general apearance and in the presence of a penetrating umbilicus; but differs in having a projecting, tilted protoconch and early whorls much like those of *S. terrae-novae*; also the margin of the basal plate is not bent forward so strongly where it bounds the umbilicus.

Genus POLINICES Montfort, 1810.

Type: *Natica brunnea* Link (=*N. mammilaris* Lamk.)

In a revision of the Naticidae of New Zealand, the writer (Marwick 1924) used the genus *Uber* of Humphries having overlooked Opinion 51 of the International Commission on Zoological Nomenclature. This was kindly pointed out in a letter by Dr. W. P. Woodring.

Polinices blaesus n. sp. (Fig. 62.)

Shell of moderate size, spire relatively high; body-whorl compressed for some distance below suture for last half whorl. *Suture* ill defined. *Surface* smooth. *Aperture* semilunar. *Outer lip* joining suture at about 85° but curving round to retreat rapidly in a broad curve. *Apertural callus* moderate, with canal at posterior end along inside of projecting outer lip, and broad depression about middle subdivided by wide faint ridge; outer edge of callus opposite transverse depression drawn up in thin layer to obtuse angle on parietal bulge of whorl. *Umbilicus* restricted to merest penetrating chink.

Holotype in Dominion Museum.

Height, 32 mm.; diameter, 24 mm.

Closely related to *P. obstructus* (Marw.) but differing in poor development of transverse grooves of callus. Also the mass of the callus does not extend so far out of the aperture. The compression of the body-whorl below the suture if constant should provide ready means of identification.

Polinices lobatus (Marwick).

1924. *Uber lobatus* Marwick, *Trans. N.Z. Inst.*, vol. 55, p. 562, pl. 58, fig. 2.

The single specimen is a gerontic individual with a contracted outer lip. The apertural callus is not so well grooved and is narrower than the typical *P. lobatus,* but more specimens are required to show how constant these differences are.

Genus ODOSTOMIA Fleming, 1817.

Type: *Turbo plicatus* Montagu.

Odostomia alexanderi n. sp. (Fig. 60.)

Shell relatively large, only two last whorls remaining. *Penultimate* whorl but slightly convex, body-whorl elongate oval. *Surface* smooth, shining, with fairly strong growth-lines. *Suture* impressed. *Columella* with single strong fold.

Height (estimated), 10 mm.; diameter, 3 mm.

Easily distinguished from *O. georgiana* Hutton by the elongately-oval body-whorl. Although the specimen is incomplete it should be readily identifiable, and so has been given a name.

Genus SYRNOLA A. Adams, 1860.

Type: *Syrnola gracillima* A. Adams.

Syrnola wallacei n. sp. (Fig. 54.)

Shell small, elongate, conic; spire about 4 times height of aperture. Whorls nine, flat to slightly convex on spire, body-whorl rounded at periphery, base slightly convex, sloping inwards at about 45°. *Protoconch* heterostrophic, paucispiral, with large nucleus. *Suture* channelled. *Surface* smooth and shining with merest suggestion of axial ribs; body-whorl with one or two very weak spiral threads on line of suture which is below periphery. *Aperture* oval. *Outer lip* sinuous, convex below. *Columella* with strong sharp fold high up.

Holotype in collection of N.Z. Geological Survey.

Height, 4.75 mm.; diameter, 1.4 mm.

Differs from *S. semiconcava* Marsh. and Murd. and *S. menda* Finlay in more convex outline of whorl and deeper suture, and from *S. lurida* Suter and *S. tenuiplicata* Murd. and Sut. in much shorter body-whorl and stronger columellar fold.

Syrnola aclyformis n. sp. (Fig. 55.)

Shell small, elongate, conic; spire four times height of aperture. *Whorls* nine, flat, increasing very gradually; body-whorl broadly rounded at periphery. *Protoconch* heterostrophic, narrow and high. Suture scarcely indenting outline. *Surface* smooth, shining, with faint growth-lines sloping obliquely forward. *Aperture* incomplete in the single specimen; but *columella* with strong fold.

Height, 5.1 mm.; diameter, 1.4 mm.

Distinguished from other described species in New Zealand by the shallow suture, and consequent straight outline.

Genus TURBONILLA Risso, 1826.

Type: *Turbonilla typica* Dall & Bartsch.

Subgenus STRIOTURBONILLA Sacco, 1892.

Type: *Turbonilla sigmoidea* Jeffreys.

Turbonilla (Strioturbonilla) chattonensis n. sp. (Figs. 52, 53, 57, 61.)

Shell elongate, conic. *Protoconch* heterostrophic, of two and a half smooth helicoid whorls with rather small nucleus. *Post-embryonic* whorls eleven in holotype but probably reaching 14 in others, much broader than high, outlines lightly convex; body-whorl rounded at periphery. *Suture* strongly constricted. *Sculpture,* holotype with 16 (paratypes up to 22) oblique, slightly curved ribs with somewhat narrower, excavated interspaces which extend from higher suture to lower but here stop abruptly thus terminating the ribbing. Very fine spiral grooves occupy the rib interspaces, about 24 on the body-whorl of large specimen; base also covered with fine spirals, the interspaces slightly wider towards periphery. *Aperture* subquadrate, *columella* with fold placed high up.

Holotype in Dominion Museum.

Height, 6.75 mm.; diameter, 1.8 mm.

Paratype, height (estimated) 10 mm. ; diameter, 2.4 mm.

In shape *T. chattonensis* resembles *T. powelli* Bucknill, but the whorls are relatively much lower. *T. suteri* Powell has more convex whorls. Neither of these species has the fine spiral lirae. *T. awamoaensis* Marsh. & Murd. has strong spiral sculpture and a different outline.

Genus PROXIMITRA Finlay, 1926.

Type: *Vexillum rutidolomum* Suter.

Proximitra incisula n. sp. (Fig. 67.)

Shell somewhat small, fusiform, spire slightly shorter than aperture. Whorls seven including protoconch which consists of about

2 smooth whorls of tectiform shape with large nucleus. *Sculpture* of 14 or 15 weak axial ribs, about their own width apart on spire but more distant on body-whorl. These are crossed by numerous close spiral threads, well marked on shoulder but becoming obsolete on sides of whorls. *Aperture* elongate, not notched below; *outer lip* slightly sinuous. *Columella* with four distant folds, anterior one weak, others strong.

Height, 12.5 mm.; diameter, 6 mm.

Holotype in collection of N.Z. Geological Survey.

P. incisula is easily distinguished from others of the genus by its small size, rather plump outline and spiral sculpture of close threads well marked only on the shoulder.

Genus XYMENELLA Finlay, 1926.

Type: *Trophon pusillus* Suter.

Xymenella inambitiosa n. sp. (Figs. 65, 68.)

Shell small, broadly fusiform. *Protoconch* convex of three smooth whorls with a small tilted nucleus, two rudimentary axials near termination which is varixed. *Post-embryonic* whorls three, convex; body-whorl convex, obscurely shouldered by spiral ornamentation, retreating rapidly below to somewhat short, slightly twisted neck which bears a low ridge but no fasciole. *Sculpture*: spire-whorls with two strong distant spiral cords; body-whorl with about 9, the lower 5 crowded together on base and neck. These are crossed by strong, sharp axials about 14 per whorl giving whole surface regularly cancellate appearance. *Aperture* oval, produced into slightly-twisted canal which is not anteriorly notched. *Outer lip* strongly varixed, bearing on inner side about 5 teeth which decrease in strength anteriorly. *Columella* smooth, twisted below to the canal.

Holotype in Dominion Museum.

Height, 5 mm.; diameter, 3 mm.

Characterized by the sharp axials and small number of spirals. The axials are really sharp varices, and on some specimens they are strongly developed at one or more places on the body-whorl showing where a complete aperture had been formed and then superseded by further growth.

Genus BARYSPIRA Fischer, 1883.

Type: *Ancillaria australis* Sowerby.

Baryspira electa n. sp. (Fig. 73.)

Shell somewhat small, subcylindrical; spire about equal in height to aperture. *Callus of spire* with weak spirals. *Callus of inner lip* extending upwards to apex of spire, its outer margin in a shallow sigmoid curve. The lower part of the *columella* bears six about equal spiral folds, the top one somewhat stronger. The interspace below it bears a weak thread.

Holotype in Dominion Museum.

Height, 22 mm.; diameter, 8 mm.

Closely related to *B. hebera* (Hutton) but differing in the disposition of the apertural and spiral callus; the sinuous outer margin

on the spire being gently convex, whereas in *B. hebera* it is concave. The folds on the columella are more uniform in size and not grooved down the middle as in *B. hebera.* There are also differences in the spiral grooves of the anterior part of the shell. The same characters serve to distinguish this species from *B. subhebera,* Marwick, which has much more callus on the spire.

Genus ERATO Risso, 1826.

Type: *Cypraea cypraeola* Brocchi.

Erato marshalli n. sp. (Fig. 56.)

Shell minute, ovate, spire low. *Protoconch* slightly tilted of about 1½ smooth planorbid whorls. *Post embryonic* whorls two and a half; body-whorl convex, inflated near posterior end of outer lip, contracted below. *Suture* not covered. *Surface* smooth and shining. *Aperture* elongate, expanded posteriorly, lightly sinused anteriorly. *Outer lip* convex, thickened, bordered, with 10 fine denticules internally. *Inner lip* also with about 10 denticles, the lower ones elongated into small folds, the upper ones merging into a keel.

Holotype in Dominion Museum.

Height, 2.7 mm. ; diameter, 1.9 mm.

Differs widely in shape from the other Tertiary species.

Genus AUSTRODRILLIA Hedley, 1918.

Type: *Pleurotoma angasi* Crosse.

Austrodrillia cinctuta n. sp. (Fig. 74.)

Shell small, fusiform; spire gradate, about one and a half times height of aperture. *Protoconch* of about 1½ smooth inflated whorls. *Post-embryonic* whorls six; body-whorl retreating in shallow convexity to short, slightly twisted neck which is swollen but without fasciole. *Sculpture* of about 10 or 11 axials, bluntly tuberculate on shoulder angle but very weak on base and on shoulder, though still visible in sub-sutural band. Whole surface with close spiral threads; shoulder with four, and three on sub-sutural band; spire-whorls with four, body-whorl with about 24 below periphery, those on base stronger and more spaced. *Suture* borderd below by well marked, weakly moniliform band. *Aperture* elongate, produced below into short wide canal not sinused anteriorly. *Outer lip* with broad, rather shallow sinus between suture and periphery. *Columella* with suggestion of fold caused by swollen neck. *Inner lip* smooth, bordered on neck by shallow depression.

Holotype in Dominion Museum.

Height, 8 mm.; diameter, 3.5 mm.

Genus AUSTROTOMA Finlay, 1924.

Type: *Bathytoma excavata* Suter.

Austrotoma inaequabilis n. sp. (Fig. 71.)

Shell of moderate size, strong; spire equal in height to aperture. *Post-embryonic* whorls about six, angled above middle, with concave shoulder and vertical sides. Body-whorl contracting slowly to straight

neck which bears strongly-developed fasciole with rounded median ridge marking inner side of the narrow anterior notch. *Sculpture*: body-whorl with two strong, spaced spiral cords on periphery; above, on the concave shoulder, are fine spiral threads, and below, another strong spiral starts from about line of suture; it is the top one of about 14 between there and fasciole. Of these the upper five are stronger than the lower ones. Space between peripheral and sutural spirals with three sharp spirals of secondary strength, upper two fairly close together, and with single fine thread between them; between lower two, are three similar threads and a single one between lowest and sutural spiral. Interspaces of strong spirals on base and neck also with spiral thread. Sides of body-whorl with obsolete axial ribs. All interspaces crossed and fine spiral threads reticulated by regular growth-lines. Spire-whorls with moderately strong axial ribs about 16 per whorl, crossed by two spaced spirals at angle of shoulder, and with six weaker spirals on sides, the alternate ones being of secondary strength. *Suture* appressed. *Aperture* with a deep, narrow anterior notch. *Outer lip* with widely concave sinus on shoulder then sweeping forward in wide convexity opposite side and base. *Columella* smooth, gently bent to canal. *Inner lip* definitely limited, excavated, not quite obliterating two folds formed by edges of apertural notch.

Holotype in collection of N.Z. Geological Survey.

Height (estimated), 35 mm.; diameter, 13 mm.

The sculpture somewhat resembles that of *A. excavata* Suter, but the shape is very different.

Austrotoma toreuma n. sp. (Fig. 72.)

Shell of moderate size; spire slightly higher than aperture. *Post-embryonic* whorls about 6, angled above middle, with strongly concave shoulder and vertical sides. Body contracting relatively quickly to short almost straight neck which bears well marked fasciole strongly ridged down the middle. *Sculpture,* about 25 forward-sloping axial ribs per whorl, commencing at shoulder angle and dying out on base. Spire-whorls with six strong, spaced spiral cords, interspace of 3rd and 4th on penultimate whorl with a single spiral thread. Shoulder with five spaced spiral threads the outer one stronger than rest. Body-whorl with 16 strong, spaced spiral cords, top three a little closer and inclined to be nodulous where crossing axials; on shoulder, are now six threads, outer one almost as strong as the ones on sides and base. The single interstitial thread of penultimate whorl continues on to body and interspace below it also develops one, but the other interspaces do not. Shoulder and interspaces crossed by very strong regular growth-lines. *Suture* appressed. *Aperture* oblong, with deep, narrow, anterior notch. *Outer lip* with wide, concave sinus on shoulder; convex below. *Columella* smooth, gently bent to canal. *Inner lip* definitely limited, excavated, not quite obliterating traces of the fasciole.

Holotype in collection of N.Z. Geological Survey.

Height, 30 mm.; diameter, 12 mm.

Easily distinguished from *A. inaequabilis* by the very strong sculpture, and general absence of interstitial spirals, and from *A.*

scopalveus Fin. by the relatively higher spire, more slender shape and persistence of axial ribbing on the body. In the last respect it resembles *A. robusta* (Hutton) but differs from that species in shape.

Genus PHENATOMA Finlay, 1924.

Type: *Pleurotoma novaezelandiae* Reeve.

Subgenus CRYPTOMELLA Finlay, 1924.

Type: *Leucosyrinx transenna* Suter.

Phenatoma (Cryptomella) crassispiralis n, sp. (Fig. 75.)

Shell small, narrowly fusiform; spire higher than aperture. *Protoconch* conic, of 4 or 5 whorls, the last quarter angled and bearing some broad axial ribs. *Post embryonic* whorls four and a quarter; body-whorl contracting gradually to neck which has no fasciole but is noticeably swollen. *Sculpture*: angle of shoulder with strong, smooth cord; steeply inclined, slightly concave shoulder bears two weaker spirals, between these and between top one and suture is fine spiral thread. On spire-whorls below shoulder-angle there is one fine cord, but body has seven of these on side and base, some interspaces with fine thread beginning on last half whorl. Neck with five spiral cords weaker than basal ones. Whole shell with strong, regular, spaced growth-ridges in interspaces and on some of the spirals. *Aperture* elongate, produced below into wide, slightly twisted canal which is lightly sinused anteriorly. *Outer lip* with narrow fairly deep sinus just above shoulder-angle, apex of sinus marked by lower shoulder-cord. *Columella* with broad strong fold corresponding to the swelling on neck and sinus of anterior canal. *Inner lip* smooth, definitely limited, excavated.

Holotype in Dominion Museum.

Height, 6 mm.; diameter, 2.5 mm.

Easily distinguished from *P. transenna* Suter and *P. antecostata* Suter by the strong basal spirals.

Genus ACUMINIA Dall, 1908.

Type: *Terebra lanceata* Linné.

Acuminia transitorsa n. sp. (Fig. 69.)

Shell of moderate size, acuminate, turriculate. *Spire* 3½ times height of aperture. *Whorls* cylindrical, bulging noticeably just below the suture, body-whorl with base quickly contracting to short, slightly twisted neck bearing well marked fasciole which is sharply limited exteriorly by narrow ridge. *Protoconch* not preserved in available specimens but probably polygyrate with small nucleus. *Sculpture* of about 22 low, narrow, flexuous axials with wide flat interspaces. *Aperture* rhomboid, produced below into deeply-notched canal. *Outer lip* with broad shallow sinus above and another on base. *Columella* smooth, twisted to canal but with no other fold.

Holotype in collection of N.Z. Geological Survey.

Height, about 42 mm.; diameter, 8.5 mm.

This shell is readily distinguished from the common one at Target Gully by the more-transverse coiling of the whorls owing to

their greater comparative width. Also the well-developed bulge below the suture gives a more-strongly gradate outline. Suter always identified the Target Gully shell as his *T. orycta,* but the type of that species is too poorly preserved for diagnosis. Topotypes should be collected and compared with the Target Gully specimens.

Acuminia suteri n. sp. (Fig. 70.)

Shell elongate, conic; spire about twice height of aperture. *Protoconch* polygyrate, subconic, with small nucleus. *Post-embryonic* whorls seven, almost flat on spire. Body-whorl angled at periphery which is followed by suture. Base convex, contracting quickly to short twisted neck which bears strongly marked fasciole bounded exteriorly by a ridge. *Sculpture*: each later whorl with 14 strong, narrow axial ribs with wide concave interspaces. The ribs are slightly higher at both ends and stop suddenly just below the periphery. Whole surface with numerous, close, waved lirae. *Aperture* subquadrangular, produced below into short twisted canal with deep anterior notch. *Columella* smooth, twisted below to form the canal. *Inner lip* smooth, obliterating sculpture of base and fasciole apparently by solution.

Holotype in collection of N.Z. Geological Survey.

Height, 13.5 mm.; diameter, 5 mm.

Distinguished by the broad apical angle, angled periphery and quickly-contracting base.

Genus ACTEON Montfort, 1810.

Type: *Voluta tornatilis* Linné.

Acteon chattonensis n. sp. (Fig. 66.)

Shell somewhat small. *Protoconch* low, nucleus tilted inwards. *Post-embryonic* whorls about 3½. *Suture* plainly marked, inclined to become channelled on weathering. *Sculpture*: spire-whorls smooth, last with spiral line bordering suture; body-whorl with two incised spiral lines below suture then smooth over curve of shoulder. Between line of suture and anterior end of body are about 17 incised, spaced spirals, upper four or five distant and having a weaker spiral in each interspace, lowest ones close together, the interspaces being like threads. Faint regular growth-lines cover whole shining surface and are stronger in the spiral grooves. *Columella* with a single strong fold.

Holotype in collection of N.Z. Geological Survey.

Height, 4.2 mm.; diameter, 2.75 mm.

Genus RINGICULA Deshayes, 1838.

Type: *Auricula ringens* Lamarck.

Ringicula castigata n. sp. (Fig. 64.)

Shell minute, ovate; spire about ⅔ height of aperture. *Whorls* about four, convex. *Protoconch* smooth, paucispiral, with slightly-tilted nucleus. *Sculpture* of distant incised lines beginning about end of second whorl, but weak on spire. *Penultimate whorl* with 6 spirals

on the side, a smooth band, caused by the omission of a spiral on curve of shoulder, above this a spiral groove forms a border below suture. *Body-whorl* with two grooves close below suture, then smooth space, then about 16 or 18 grooves, top 5 of which are further spaced than others. *Outer lip* much thickened and reflexed, curving forward below. *Columella* with two strong folds. *Inner lip* forming another calloused fold on the parietal wall.

Holotype in collection of N.Z. Geological Survey.

Height, 1.5 mm.; diameter, 1.1 mm.

The smooth band is not always present, for on some specimens the spirals are continuous.

REFERENCES.

COSSMANN, M., 1918. *Essais de Paléoconchologie Comparée,* vol. 11.

FINLAY, H. J., 1926. A Further Commentary on N.Z. Molluscan Systematics. *Trans. N.Z. Inst.,* vol 57.

FINLAY and McDOWALL, 1924. Preliminary Note on the Clifden Beds. *Trans. N.Z. Inst.,* vol. 55.

HARRIS, G. F., 1897. Catalogue of Tertiary Mollusca, British Museum, Pt. 1 (Australasia).

IHERING, H. VON, 1907. Les mollusques Fossiles du Tertiaire et du Crétacé Supérieur de l'Argentine. *Anales del Museo Nacional de Buenos Aires,* Ser. 3, tome 7.

IREDALE, T., 1924. Results from Roy Bell's Collections. *Proc. Linn. Soc. N.S.W.,* vol. 49, pt. 3.

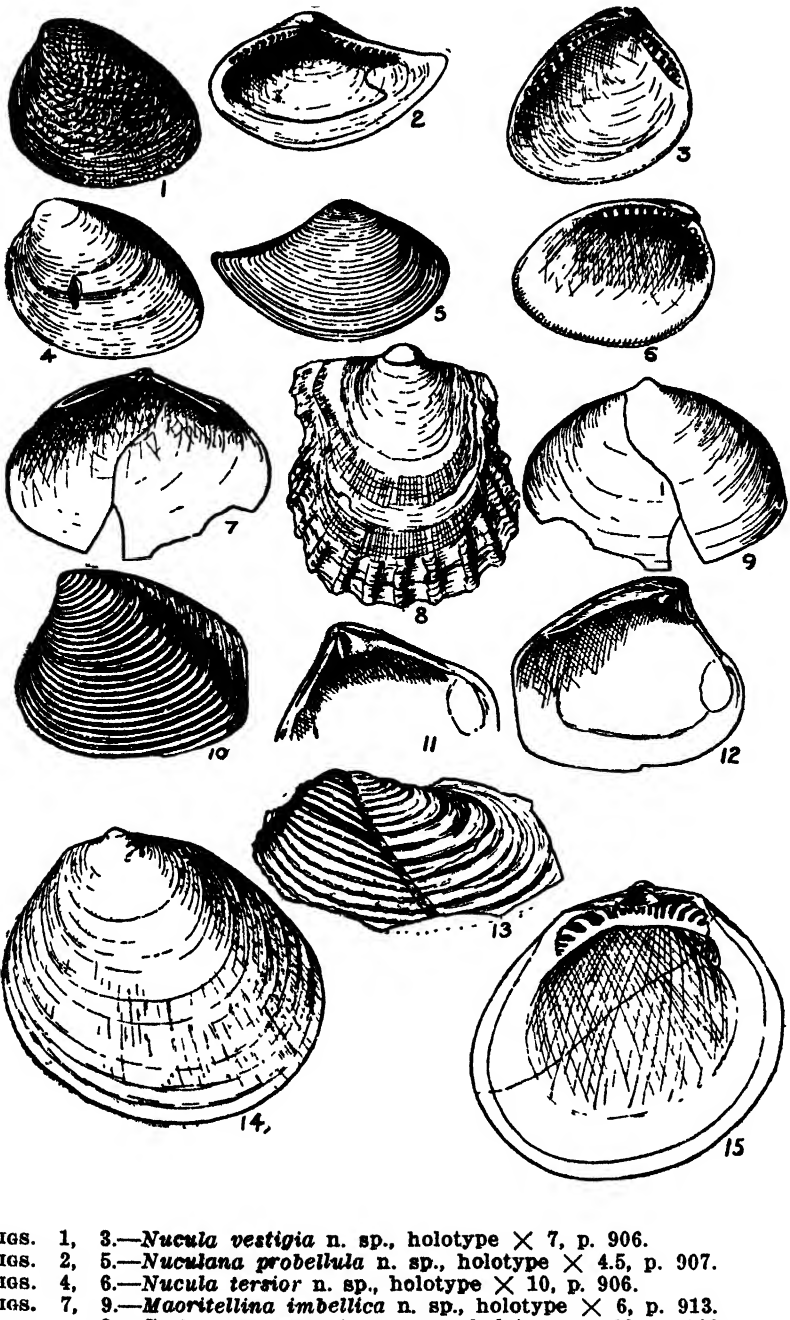
MARSHALL, P., 1917. (a) The Wangaloa Beds, (b) Fossils and Age of the Hampden Beds. *Trans. N.Z. Inst.,* vol. 49.

MARWICK, J., 1924. Tertiary and Recent Naticidae and Naricidae of New Zealand. *Trans. N.Z. Inst.,* vol. 55.

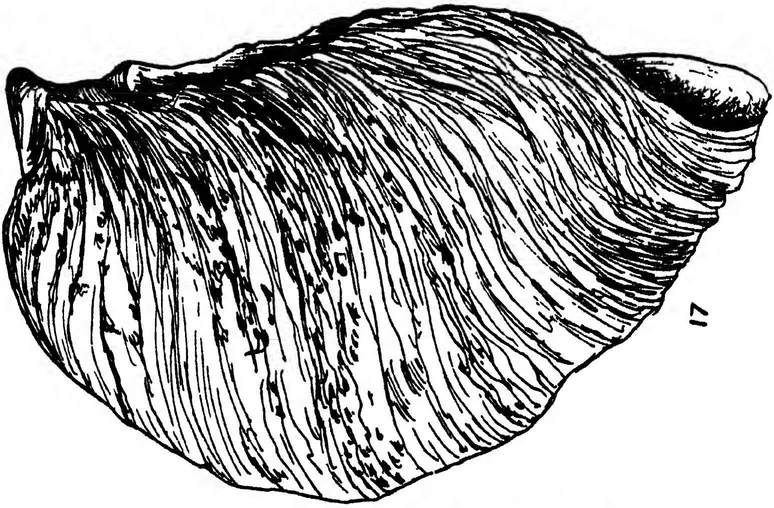
—— 1928. Tertiary Mollusca of Chatham Islands. *Trans. N.Z. Inst.* vol. 58.

SUTER, H., 1915. Revision of the Tertiary Mollusca of New Zealand. *N.Z. Geological Survey Pal. Bulletin,* No. 3.

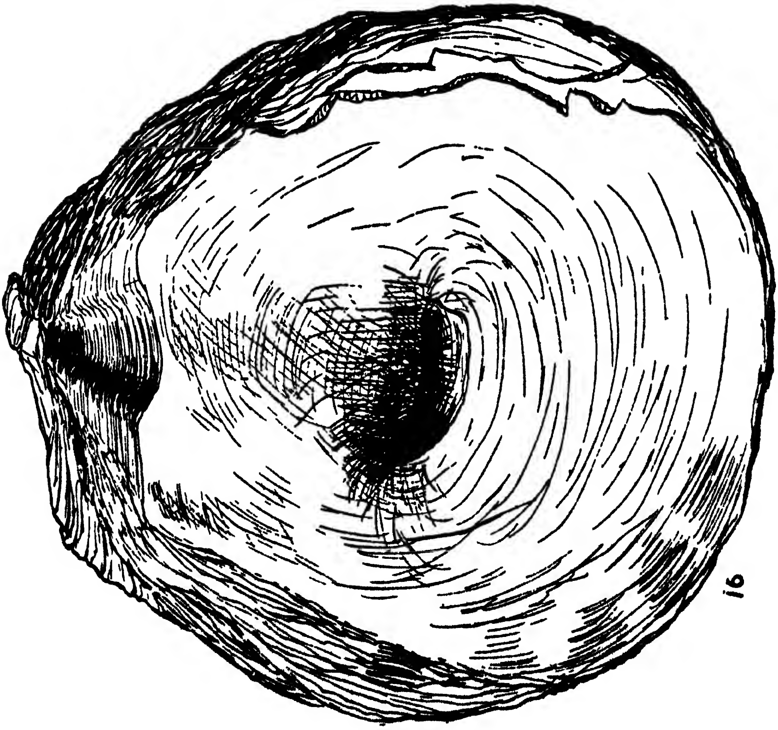
SUTER, H., 1921. Lists of N.Z. Tertiary Mollusca. *N.Z. Geological Survey Pal. Bulletin,* No. 8.



FIGS. 1, 3.—*Nucula vestigia* n. sp., holotype × 7, p. 906.
FIGS. 2, 5.—*Nuculana probellula* n. sp., holotype × 4.5, p. 907.
FIGS. 4, 6.—*Nucula tersior* n. sp., holotype × 10, p. 906.
FIGS. 7, 9.—*Maoritellina imbellica* n. sp., holotype × 6, p. 913.
FIG. 8.—*Cyclopecten compitum* n.sp., holotype × 20, p. 909.
FIGS. 10, 11, 12.—*Chattonia animula* n. gen. n. sp., holotype and paratype × 6, p. 909.
FIG. 13.—*Pholadidea increnata* n. sp., holotype × 2, p. 914.
FIGS. 14, 15.—*Limopsis parma* n. sp., holotype × 1.5, p. 908.

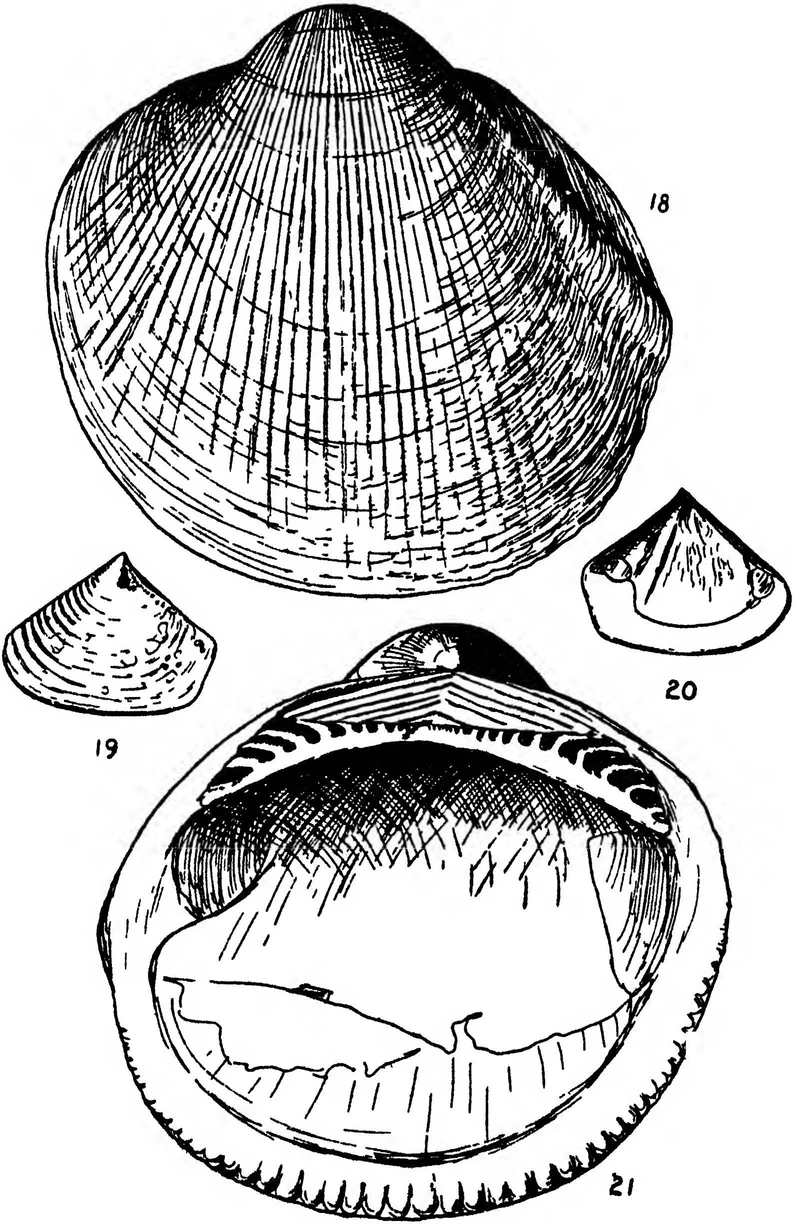


17

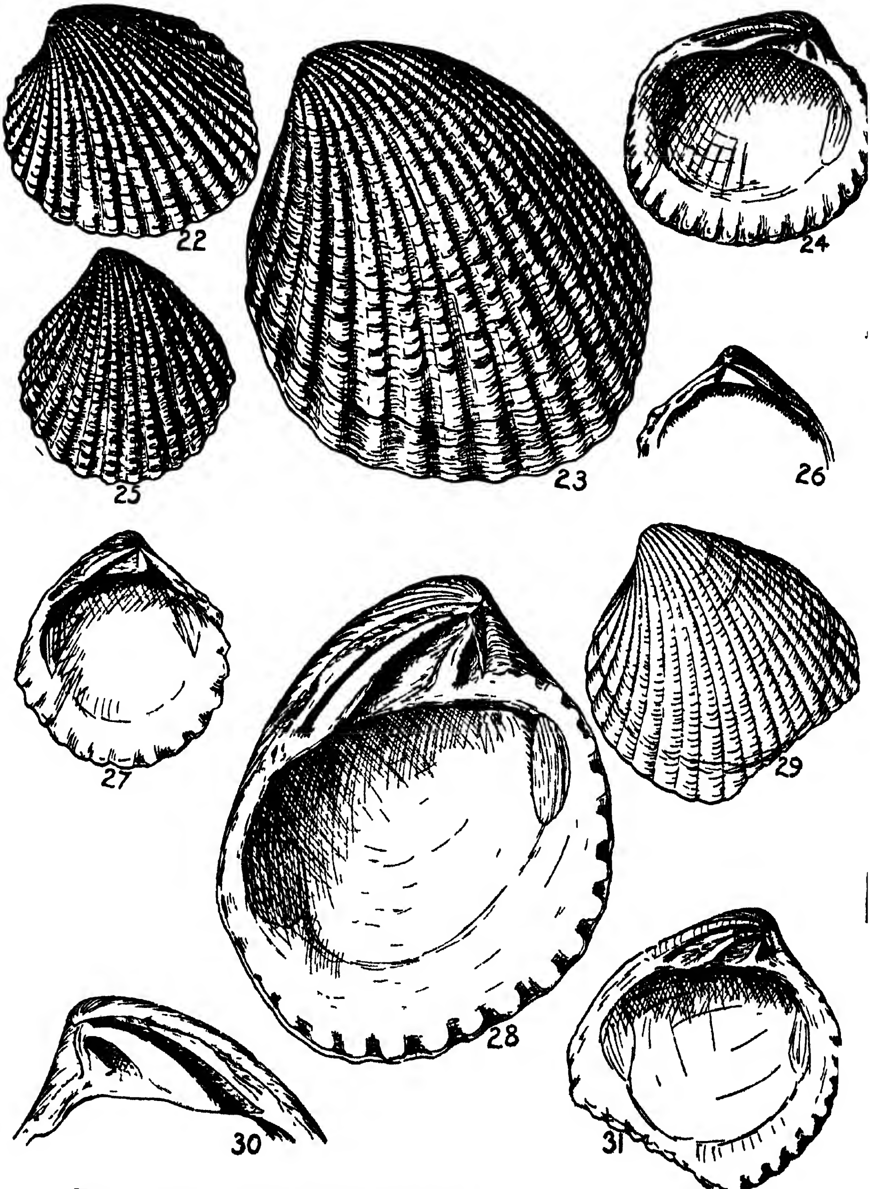


16

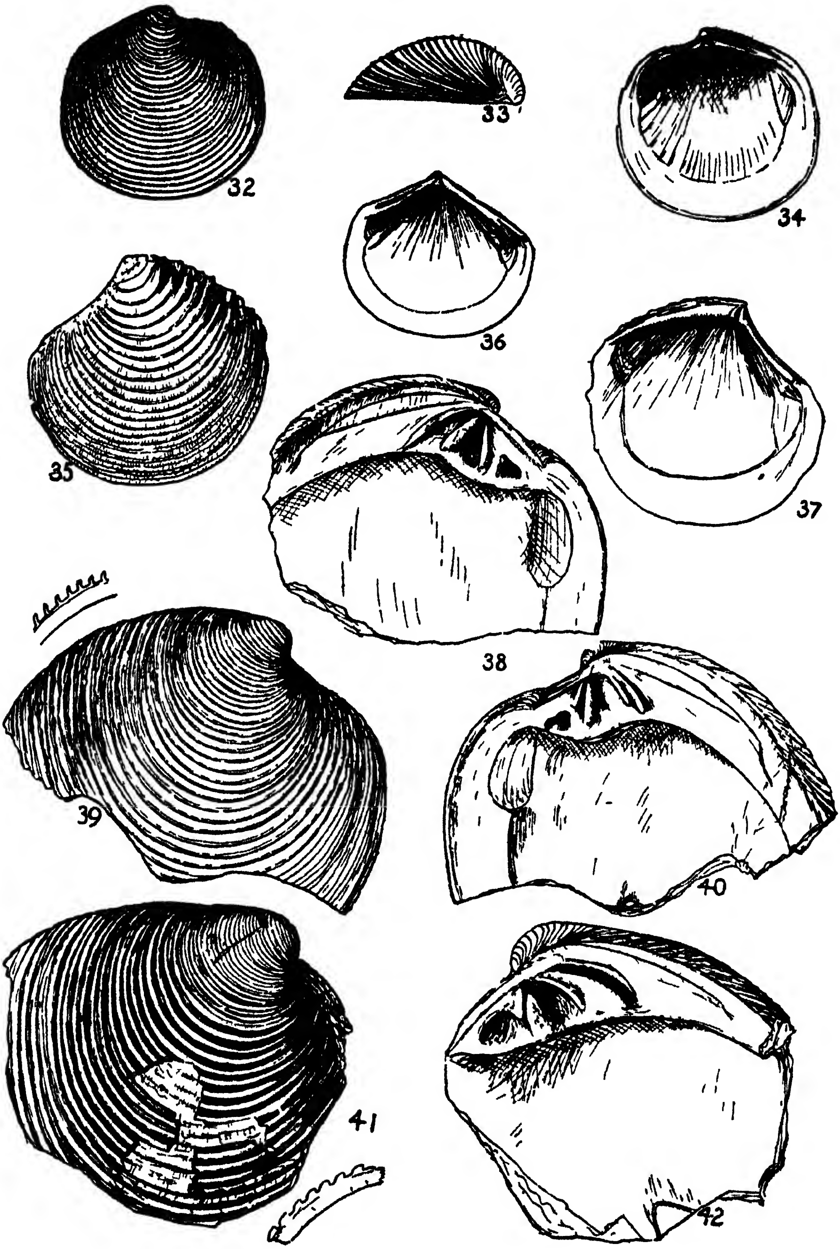
Figs. 16, 17.—*Ostrea* (*Gigantostrea*) *wollastoni* Finlay. × .6, p. 908.



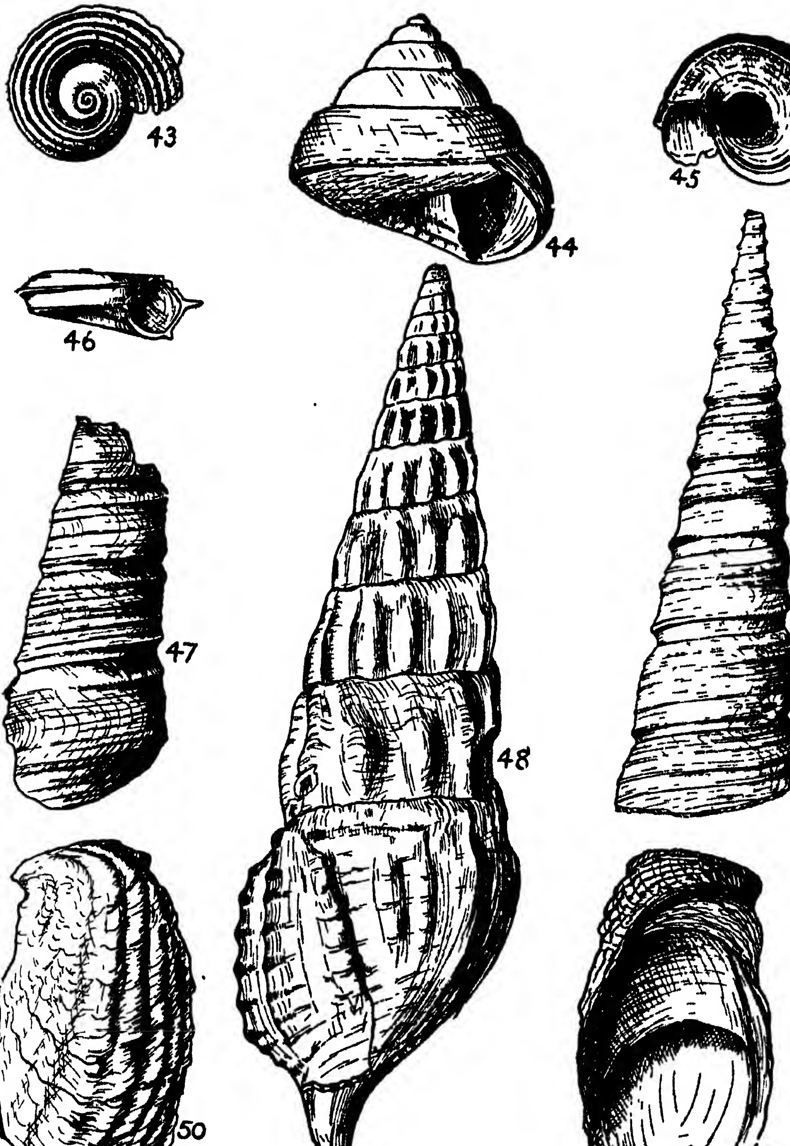
FIGS. 18, 21.—*Glycymeris thomsoni* n. sp., holotype × 1, p. 907.
FIGS. 19, 20.—*Myadora delta* n. sp., holotype × 3, p. 914.



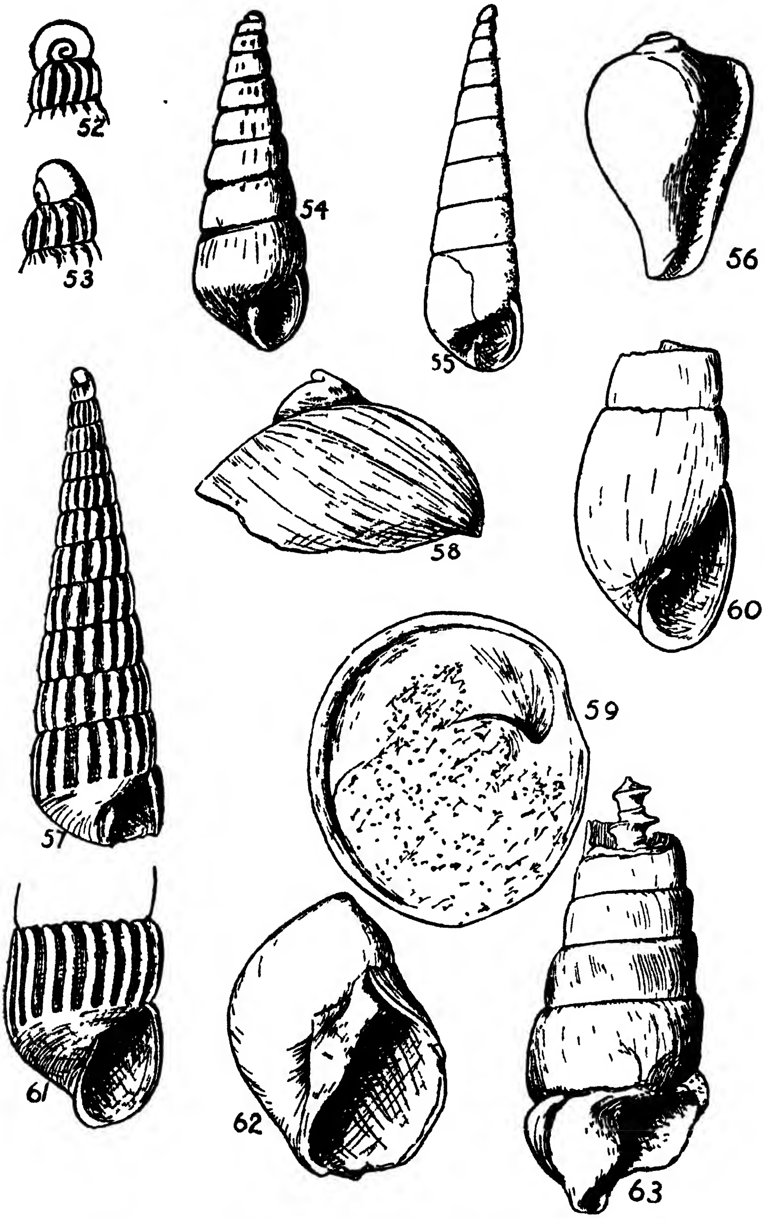
FIGS. 22, 24.—*Venericardia caelebs* n. sp., holotype × 1.2, p. 911.
FIGS. 25, 26, 27.—*Venericardia* (*Pleuromeris*) *prolutea* n. sp., holotype and paratype × 5.5, p. 911.
FIGS. 23, 28, 30.—*Venericardia christiei* n. sp., holotype and paratype × 1.2, p. 910.
FIGS. 29, 31.—*Venericardia pseutella* n. sp., holotype × 3.3, p. 910.



FIGS. 32, 33, 34.—*Gonimyrtea bucculenta* n. sp., holotype × 4.3, p. 912.
FIGS. 35, 36, 37.—*Eulopia (Notomyrtea) staminifera* n. sp., holotype and paratype × 5.4, p. 911.
FIGS. 38, 39, 40.—*Dosinia (Raina) sodalis* n. sp., holotype × 1, p. 913.
FIGS. 41, 42.—*Dosinia (Raina) imperiosus* n. sp., holotype × 1, p. 914.



Figs. 43, 45, 46.—*Elachorbis duplicarina* n. sp., holotype × 13, p. 915.
Fig. 44.—*Antisolarium vixincisum* n. sp., holotype × 9.5, p. 915.
Figs. 47, 49.—*Zeacolpus chattonensis* n. sp., paratype × 1.2, holotype × 2.4, p. 916.
Fig. 48.—*Pyrazus sutherlandi* n. sp., holotype × 1.2, p. 917.
Figs. 50, 51.—*Maoricrypta salebrosa* n. sp., holotype × 1.2, p. 918.



FIGS. 52, 53, 57, 61.—*Turbonilla (Strioturbonilla) chattonensis* n. sp., holotype and paratype × 10, p. 920.
FIG. 54.—*Syrnola wallacei* n. sp., holotype × 10, p. 919.
FIG. 55.—*Syrnola aclyformis* n. sp., holotype × 10, p. 920.
FIG. 56.—*Erato marshalli* n. sp., holotype × 12, p. 922.
FIGS. 58, 59.—*Sigapatella mapalia* n. sp., holotype × 5, p. 918.
FIG. 60.—*Odostomia alexanderi* n. sp., holotype × 7, p. 919.
FIG. 62.—*Polinices blaesus* n. sp., holotype ×1.2, p. 919.
FIG. 63.—*Zefallacia chattonensis* n. sp., holotype × 1.2, p. 917.

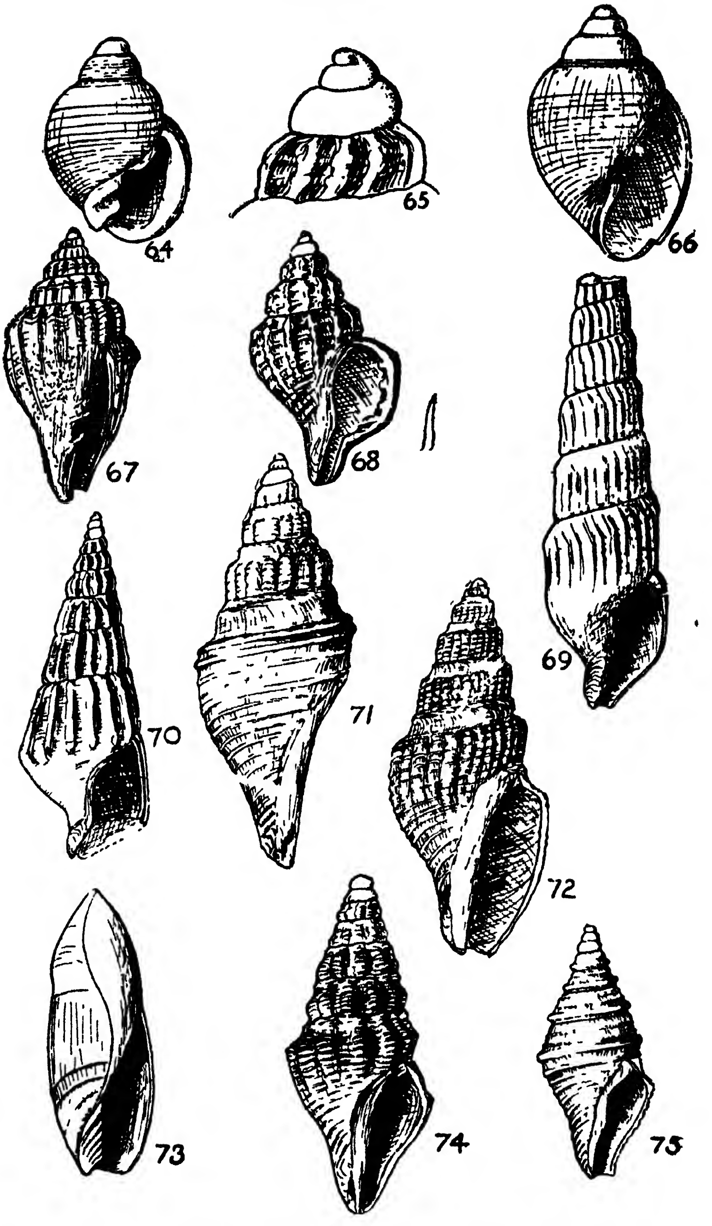
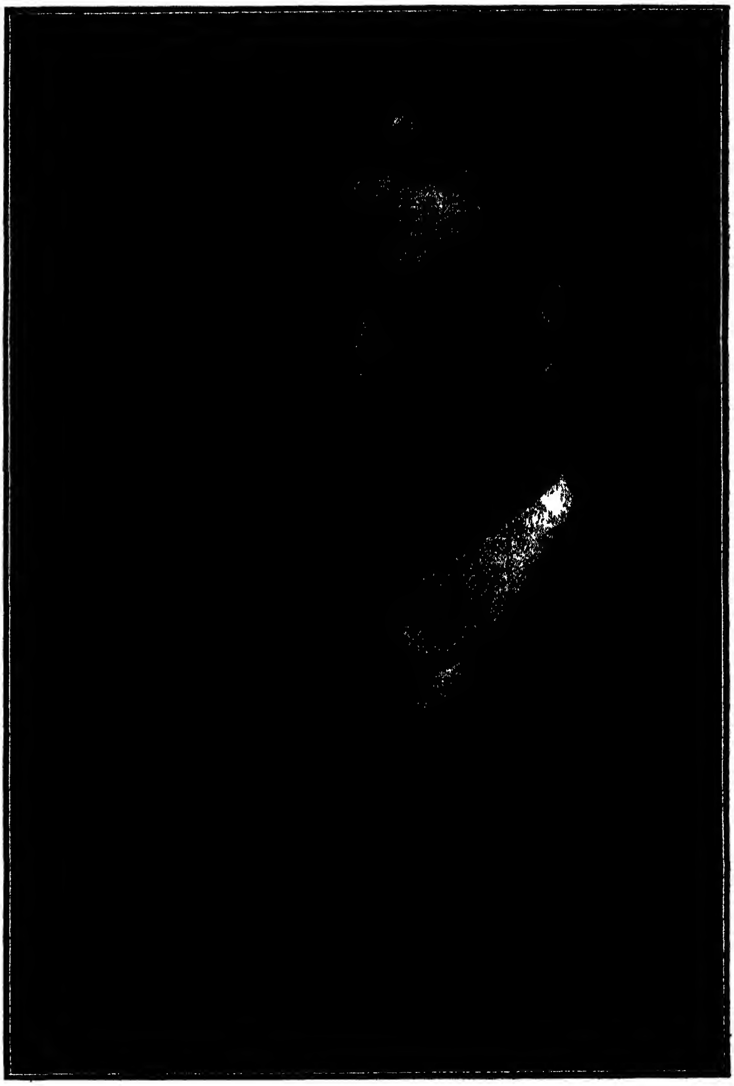


FIG. 64.—*Ringicula castigata* n. sp., holotype × 20, p. 925.
FIGS. 65, 68.—*Xymenella inambitiosa* n. sp., holotype × 7, p. 921.
FIG. 66.—*Acteon chattonensis* n. sp., holotype × 8, p. 925.
FIG. 67.—*Proximitra incisula* n. sp., holotype × 3, p. 920.
FIG. 69.—*Acuminia transitorsa* n. sp., holotype × 2, p. 924.
FIG. 70.—*Acuminia suteri* n. sp., holotype × 3.7, p. 925.
FIG. 71.—*Austrotoma inaequabilis* n. sp., holotype × 1.8, p. 922.
FIG. 72.—*Austrotoma toreuma* n. sp., holotype × 1.8, p. 923.
FIG. 73.—*Baryspira electa* n. sp., holotype × 1.8, p. 921.
FIG. 74.—*Austrodrillia cinctuta* n. sp., holotype × 6, p. 922.
FIG. 75.—*Phenatoma* (*Cryptomella*) *crassispiralis* n. sp., holotype × 6, p. 924.



J. ALLAN THOMSON

BORN 1881—DIED 1928

(From "Journal of Science and Technology." Vol. 10, No. 2)

Face p. 935.

OBITUARY.

JAMES ALLAN THOMSON. 1881-1928.

James Allan Thomson, who died on 6th May, was one of the most distinguished of the men of science New Zealand has produced. Born in Dunedin in 1881 he had a successful school and college career, and won all the the usual honours and distinctions that the University confers on its students who display capacity and originality. He specialized in Geology, having inherited a marked bent in the direction of natural science from his father, G. M. Thomson, a naturalist of no mean ability, an aptitude developed and stimulated by the influence of Dr. P. Marshall who had a little earlier been appointed to the charge of this geological department at Otago University. His marked academic ability, his keen enthusiasm in University matters, and his fondness for and success in athletics were very largely responsible for his being elected the first Rhodes Scholar for New Zealand. He was also awarded the Exhibition Science Scholarship, and in the year 1905 he entered at St. John's College, Oxford, where he won the Burdett-Coutts Scholarship in Geology and was appointed Demonstrator and finally, in 1907, Lecturer in the subject at the College. Next year he was appointed Demonstrator in Petrology to the University of Oxford—a new position. He had the good fortune to be associated in his work there with Professor Sollas, whose wide and varied scientific attainments, as well as his inspiring personality, were responsible for broadening and developing an intellect naturally susceptible to such influences.

In 1908 he went to Australia with Dr. Maclaren, to report specially on the geological conditions of the West Australian goldfields, his training in petrology both at Dunedin and at Oxford being of the highest value in dealing with such a difficult problem, and it was for scientific work on the petrology of the West Australian gold bearing rocks and their relations that he was in 1912 awarded the degree of D.Sc. by the University of New Zealand.

In 1909 he married Miss Gertrude Kean, who pre-deceased him by several years, and they have left two children to maintain and keep burning the lamps of life and learning.

In 1910 he was proposed as chief of the scientific staff to the Scott Antarctic Expedition, but unfortunately failed to pass the medical test, and after an interval spent in recruiting his health, having contracted, at Sydney, a chest trouble which never left him, he was appointed Palaeontologist to the New Zealand Geological Survey, a new post which afforded him opportunities for open-air work for a great part of the summer season under most favourable conditions. During the time he acted in that capacity he amassed a fund of knowledge and acquired an intimate acquaintance with the field occurrence of our Tertiary Mollusca and, above all, of the Brachiopoda which later helped him substantially with what must be regarded as his most important scientific work.

In 1914 he was appointed to the position of Director of the Dominion Museum in Wellington, a post he filled till his death, and in the same year he was appointed one of the four Government representatives on the Board of Governors of the New Zealand Institute.

While carrying on his duties as Director he continued his geological work as occasion allowed, although his health was not good, but his superabundant optimism and unfailing courage enabled him to carry out investigations that a less determined and enthusiastic man would have found impossible. His geological work was mostly concerned with our Cretaceous and Tertiary sequence, and to him may be credited very largely the use of stage names, the conception of the existence of diastrophic provinces in the New Zealand area, and the recognition of the weakness of the Lyellian criterion for the determination of the age of the different horizons of our Tertiary sequence on the basis of the percentage of living species unless due weight be given to the possible presence of species at particular horizons by 'implication,' a criterion which demands a more thorough knowledge of the occurrence of species in various localities than we possess at present.

Thomson's main work, however, concerns the Brachiopods, of which he made a thorough study, basing his conclusions on material collected during the time spent in Palaeonlogical field work and on the collections in various museums and in the hands of the New Zealand Geological Survey. He also had the Brachiopod material collected during the Australasian Antarctic Expedition submitted to him for examination, and his report on the 'Brachiopoda' is one of the numbers issued by the publication committee of that expedition. In this he summarises ably the evidence for the existence of land connections in the southern region of the Southern Hemisphere from the Mesozoic Era onward with particular reference to the connections existing in late Tertiary times. This monumental work established his reputation as an authority on the group. During the period between its issue (1918) and his death he contributed various papers on Brachiopod Morphology to the *Transactions of the New Zealand Institute*, the *Annals and Magazine of Natural History* and to other publications, and finally completed his labours in that direction by the production of the volume on 'Brachiopod Morphology,' which embodied his mature opinions on the structure and phyllogeny of the Tertiary members of the group. This work appeared only a few months before his death, and accentuated the loss to science that this untimely event entailed.

In addition to these lines of investigation, Thomson devoted considerable time to other departments of geology, specially to the framing of a satisfactory scheme of rock classification, to the study of our volcanoes, and those of the mid-Pacific Region, the latter following on a visit he paid to Hawaii and Samoa on the occasion of the meeting of the First Pan-Pacific Science Conference in Honolulu.

An idea of his activity may be gathered on a reading of the list of his papers published from 1906 to 1927, given in the *New Zealand Journal of Science and Technology* for July, 1928, which contains no less than 68 titles.

I have dealt at length with his achievements in the domain of pure science, but he also filled the position of Director of the Dominion Museum with distinction. Such a position demands a wide range of scientific attainment and an attitude sympathetic to many phases of thought, and this he exhibited in a marked degree. In his management of the Museum he was hampered with lack of funds, the incubus of an old and unsuitable building and the absence of any marked public interest in the institution, difficulties which he did his best to overcome in spite of health conditions. He was ever considerate of the interests of other museums, and no fairer minded colleague could possibly have existed or one more careful of the feelings or sympathetic with the ambitions and hopes of others. Purely in the desire of helping other institutions he arranged for the first Museum Conference in New Zealand and did his best to see that its recommendations were carried into effect.

He was Secretary to the Board of Science and Art from its inception in 1916, and editor of the *New Zealand Journal of Science and Technology*, issued by the Board in 1918, until 1921, when ill-health compelled him to surrender the editorial duties to others.

As head of the Dominion Museum he was frequently called on by the Government officials to advise them on all sorts of questions arising in connection with scientific matters and scientific institutions, and with the enforcement of regulations with regard to permits, etc., and in all cases he acted not only with most scrupulous fairness to the Government but also so as to smooth out any difficulties in the way of wishes of the institutions or persons concerned. He was the soul of tact and of upright and sympathetic administration.

He was very largely responsible for the initiation of a Government Department for the correlation and development of scientific research within the Dominion, and he furinshed a noteworthy report in connection therewith whose lines are very closely followed in the present Department of Scientific and Industrial Research.

Enough has been said to indicate the influence which he exerted on various phases of the scientific activity of the country, and it will be generally recognized that his schemes were built on broad and solid foundations. The New Zealand Institute has endorsed this opinion in various ways. He was elected an Original Fellow of the Institute, was awarded the Hutton Medal for his researches in Geology, represented it on various occasions at conferences abroad, and was elected its President at the meeting held in January of the present year, a position he held at his death.

In addition to his scientific attainments he had a generous disposition and a cheerful and optimistic outlook on life; he was an agreeable and a generous companion, and specially so in the field, with a keen sense of humour, and was one who regarded his duty to his country, his profession, his friends, as well as those he differed with, as above all personal consideration whatsoever.

R.S.

APPENDIX.

NEW ZEALAND INSTITUTE ACT, 1908.
1908, No. 130.

AN ACT to consolidate certain Enactments of the General Assembly relating to the New Zealand Institute.

BE IT ENACTED by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows:—

1. (1.) The Short Title of this Act is the New Zealand Institute Act, 1908.

(2.) This Act is a consolidation of the enactments mentioned in the Schedule hereto, and with respect to those enactments the following provisions shall apply: —

(*a*) The Institute and Board respectively constituted under those enactments, and subsisting on the coming into operation of this Act, shall be deemed to be the same Institute and Board respectively constituted under this Act without any change of constitution or corporate entity or otherwise; and the members thereof in office on the coming into operation of this Act shall continue in office until their successors under this Act come into office.

(*b*) All Orders in Council, regulations, appointments, societies incorporated with the Institute, and generally all acts of authority which originated under the said enactments or any enactment thereby repealed, and are subsisting or in force on the coming into operation of this Act, shall enure for the purposes of this Act as fully and effectually as if they had originated under the corresponding provisions of this Act, and accordingly shall, where necessary, be deemed to have so originated.

(*c*) All property vested in the Board constituted as aforesaid shall be deemed to be vested in the Board established and recognised by this Act.

(*d*.) All matters and proceedings commenced under the said enactments, and pending or in progress on the coming into operation of this Act, may be continued, completed, and enforced under this Act.

2. (1.) The body now known as the New Zealand Institute (hereinafter referred to as "the Institute") shall consist of the Auckland Institute, the Wellington Philosophical Society, the Philosophical Institute of Canterbury, the Otago Institute, the Hawke's Bay Philosophical Institute, the Nelson Institute, the Westland Institute, the Southland Institute, and such others as heretofore have been or may hereafter be incorporated therewith in accordance with regulations heretofore made or hereafter to be made by the Board of Governors.

(2.) Members of the above-named incorporated societies shall be *ipso facto* members of the Institute.

3. The control and management of the Institute shall be vested in a Board of Governors (hereinafter referred to as "the Board"), constituted as follows:—

The Governor:

The Minister of Internal Affairs:

Four members to be appointed by the Governor in Council, of whom two shall be appointed during the month of December in every year.

Two members to be appointed by each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine.

One member to be appointed by each of the other incorporated societies during the month of December in each alternate year; and the next year in which such an appointment shall be made is the year one thousand nine hundred and nine.

4. (1.) Of the members appointed by the Governor in Council, the two members longest in office without reappointment shall retire annually on the appointment of their successors.

(2.) Subject to the last preceding subsection, the appointed members of the Board shall hold office until the appointment of their successors.

5. The Board shall be a body corporate by the name of the "New Zealand Institute," and by that name shall have perpetual succession and a common seal, and may sue and be sued, and shall have power and authority to take, purchase, and hold lands for the purposes hereinafter mentioned.

6. (1.) The Board shall have power to appoint a fit person, to be known as the "President," to superintend and carry out all necessary work in connection with the affairs of the Institute, and to provide him with such further assistance as may be required.

(2.) The Board shall also appoint the President or some other fit person to be editor of the Transactions of the Institute, and may appoint a committee to assist him in the work of editing the same.

(3. The Board shall have power from time to time to make regulations under which societies may become incorporated with the Institute, and to declare that any incorporated society shall cease to be incorporated if such regulations are not complied with; and such regulations on being published in the *Gazette* shall have the force of law.

(4.) The Board may receive any grants, bequests, or gifts of books or specimens of any kind whatsoever for the use of the Institute, and dispose of them as it thinks fit.

(5.) The Board shall have control of the property from time to time vested in it or acquired by it; and shall make regulations for the management of the same, and for the encouragement of research by the members of the Institute; and in all matters, specified or unspecified shall have power to act for and on behalf of the Institute.

7. (1.) Any casual vacancy in the Board, howsoever caused, shall be filled within three months by the society or authority that ap-

pointed the member whose place has become vacant, and if not filled within that time the vacancy shall be filled by the Board.

(2.) Any person appointed to fill a casual vacancy shall only hold office for such period as his predecessor would have held office under this Act.

8. (1.) Annual meetings of the Board shall be held in the month of January in each year, the date and place of such annual meeting to be fixed at the previous annual meeting.

(2.) The Board may meet during the year at such other times and places as it deems necessary.

(3.) At each annual meeting the President shall present to the meeting a report of the work of the Institute for the year preceding, and a balance-sheet, duly audited, of all sums received and paid on behalf of the Institute.

9. The Board may from time to time, as it sees fit, make arrangements for the holding of general meetings of members of the Institute, at times and places to be arranged, for the reading of scientific papers, the delivery of lectures, and for the general promotion of science in New Zealand by any means that may appear desirable.

10. The Minister of Finance shall from time to time, without further appropriation than this Act, pay to the Board the sum of five hundred pounds in each financial year, to be applied in or towards payment of the general current expenses of the Institute.

11. Forthwith upon the making of any regulations or the publication of any Transactions, the Board shall transmit a copy thereof to the Minister of Internal Affairs, who shall lay the same before Parliament if sitting, or if not, then within twenty days after the commencement of the next ensuing session thereof.

SCHEDULE.

Enactments consolidated.

1903, No. 48. The New Zealand Institute Act, 1903.

NEW ZEALAND INSTITUTE AMENDMENT ACT, 1920.

1920, No. 3.

AN ACT to amend the New Zealand Institute Act, 1908.

[*30th July, 1920.*

BE IT ENACTED by the General Assembly of New Zealand in Parliament assembled, and by the authority of the same, as follows:—

1. This Act may be cited as the New Zealand Institute Amendment Act, 1920, and shall be read together with and deemed part of the New Zealand Institute Act, 1908.

2. Section ten of the New Zealand Institute Act, 1908, is hereby amended by omitting the words "five hundred pounds," and substituting the words " one thousand pounds."

FROM THE FINANCE ACT, 1925, No. 51.

7. (1.) The Minister of Finance shall, without further authority than this section, pay to the Board of Governors of the New Zealand

Institute the sum of one thousand five hundred pounds in each financial year, commencing with the year beginning on the first day of April, nineteen hundred and twenty-five, to be applied in or towards payment of the general expenses of the Institute.

(2.) This section is in substitution for section ten of the New Zealand Institute Act, 1908, and that section and the New Zealand Institute Amendment Act, 1920, are hereby repealed.

REGULATIONS.

THE following are the regulations of the New Zealand Institute under the Act of 1903:—*

The word "Institute" used in the following regulations means the New Zealand Institute as constituted by the New Zealand Institute Act, 1903.

INCORPORATION OF SOCIETIES.

1. No society shall be incorporated with the Institute under the provisions of the New Zealand Institute Act, 1903, unless such society shall consist of not less than twenty-five members, subscribing in the aggregate a sum of not less than £25 sterling annually for the promotion of art, science, or such other branch of knowledge for which it is associated, to be from time to time certified to the satisfaction of the Board of Governors of the Institute by the President for the time being of the society.

2. Any society incorporated as aforesaid shall cease to be incorporated with the Institute in case the number of the members of the said society shall at any time become less than twenty-five, or the amount of money annually subscribed by such members shall at any time be less than £25.

3. The by-laws of every society to be incorporated as aforesaid shall provide for the expenditure of not less than one-third of the annual revenue in or towards the formation or support of some local public museum or library, or otherwise shall provide for the contribution of not less than one-sixth of its said revenue towards the extension and maintenance of the New Zealand Institute.

4. Any society incorporated as aforesaid which shall in any one year fail to expend the proportion of revenue specified in Regulation No. 3 aforesaid in manner provided shall from henceforth cease to be incorporated with the Institute.

PUBLICATIONS.

5. All papers read before any society for the time being incorporated with the Institute shall be deemed to be communications to the Institute, and then may be published as Proceedings or Transactions of the Institute, subject to the following regulations of the Board of the Institute regarding publications:—

(*a*.) The publications of the Institute shall consist of—

(1.) A current abstract of the proceedings of the societies for the time being incorporated with the Institute, to be intituled "Proceedings of the New Zealand Institute";

**New Zealand Gazette*, 14th July, 1904.

(2.) And of transactions comprising papers read before the incorporated societies (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time determine to publish, to be intituled "Transactions of the New Zealand Institute."

(*b.*) The Board of Governors shall determine what papers are to be published.

(*c.*) Papers not recommended for publication may be returned to their authors if so desired.

(*d.*) All papers sent in for publication must be legibly written, typewritten, or printed.

(*e.*) A proportional contribution may be required from each society towards the cost of publishing Proceedings and Transactions of the Institute.

(*f.*) Each incorporated society will be entitled to receive a proportional number of copies of the Transactions and Proceedings of the New Zealand Institute, to be from time to time fixed by the Board of Governors.

Management of the Property of the Institute.

6. All property accumulated by or with funds derived from incorporated societies, and placed in charge of the Institute, shall be vested in the Institute, and be used and applied at the discretion of the Board of Governors for public advantage, in like manner with any other of the property of the Institute.

7. All donations by societies, public Departments, or private individuals to the Institute shall be acknowledged by a printed form of receipt and shall be entered in the books of the Institute provided for that purpose, and shall then be dealt with as the Board of Governors may direct.

Honorary Members.

8. The Board of Governors shall have power to elect honorary members (being persons not residing in the Colony of New Zealand), provided that the total number of honorary members shall not exceed thirty.

9. In case of a vacancy in the list of honorary members, each incorporated society, after intimation from the Secretary of the Institute, may nominate for election as honorary member one person.

10. The names, descriptions, and addresses of persons so nominated, together with the grounds on which their election as honorary members is recommended, shall be forthwith forwarded to the President of the New Zealand Institute, and shall by him be submitted to the Governors at the next succeeding meeting.

Additional Regulation adopted by Board of Governors on 30th January, 1923, and published in the New Zealand Gazette *of 28th May, 1925.*

10a. Vacancies in the list of honorary members shall be announced at each annual meeting of the Board of Governors, and such announcement be communicated as early as possible to each incorporated

society, and each such society shall on or before the 1st December nominate one person for each vacancy as honorary member, and the election shall take place at the next annual meeting of the Board of Governors.

GENERAL REGULATIONS.

11. Subject to the New Zealand Institute Act, 1908, and to the foregoing rules, all societies incorporated with the Institute shall be entitled to retain or alter their own form of constitution and the by-laws for their own management, and shall conduct their own affairs.

12. Upon application signed by the President and countersigned by the Secretary of any Society, accompanied by the certificate required under Regulation No. 1, a certificate of incorporation will be granted under the seal of the Institute, and will remain in force as long as the foregoing regulations of the Institute are complied with by the society.

13. In voting on any subject the President is to have a deliberate as well as a casting vote.

14. The President may at any time call a meeting of the Board, and shall do so on the requisition in writing of four Governors.

15. Twenty-one days' notice of every meeting of the Board shall be given by posting the same to each Governor at an address furnished by him to the Secretary.

16. In case of a vacancy in the office of President, a meeting of the Board shall be called by the Secretary within twenty-one days to elect a new President.

17. The Governors for the time being resident or present in Wellington shall be a Standing Committee for the purpose of transacting urgent business and assisting the officers.

18. The Standing Committee may appoint persons to perform the duties of any other office which may become vacant. Any such appointment shall hold good until the next meeting of the Board, when the vacancy shall be filled.

19. The foregoing regulations may be altered or amended at any annual meeting, provided that notice be given in writing to the Secretary of the Institute not later than 30th November.

The following additional regulations, and amendment to regulations, were adopted at a general meeting of the Board of Governors of the New Zealand Institute, held at Wellington on the 30th January, 1918, and at Christchurch on the 3rd February, 1919. (See *New Zealand Gazette*, No. 110, 4th September, 1919.)

REGULATIONS GOVERNING THE FELLOWSHIP OF THE INSTITUTE.

20. The Fellowship of the New Zealand Institute shall be an honorary distinction for the life of the holder.

21. The Original Fellows shall be twenty in number, and shall include the past Presidents and the Hutton and Hector Medallists who have held their distinctions and positions prior to 3rd February, 1919, and who at that date are members of the Institute. The remaining Original Fellows shall be nominated as provided for in Regula-

tion 26 (*a*), and shall be elected by the said past Presidents and Hector and Hutton Medallists.

22. The total number of Fellows at any time shall not be more than forty.

23. After the appointment and election of the Original Fellows, as provided in Regulation 21, not more than four Fellows shall be elected in any one year. The number to be elected in any year shall be decided by the Board of Governors at the previous annual meeting.

24. The Fellowship shall be given for research or distinction in science.

25. No person shall be nominated or elected as Fellow unless he has been a member of the N.Z. Institute for three years immediately preceding his nomination, or for five years at any period preceding his nomination.

26. After the appointment and election of the Original Fellows as provided in Regulation 21 there shall be held an annual election of Fellows at such time as the Board of Governors shall appoint. Such election shall be determined as follows:—

(*a*.) Each of the incorporated societies at Auckland, Wellington, Christchurch, and Dunedin may nominate not more than twice as many persons as there are vacancies, and each of the other incorporated societies may nominate as many persons as there are vacancies. Each nomination must be accompanied by a statement of the qualifications of the candidate for Fellowship.

(*b*.) Out of the persons so nominated the Fellows resident in New Zealand shall select twice as many persons as there are vacancies, if so many be nominated.

(*c*.) The names of the nominees shall be submitted to the Fellows at least six months, and the names selected by them submitted to the Governors at least three months, before the date fixed for the annual meeting of the Board of Governors at which the election is to take place.

(*d*.) The election shall be made by the Board of Governors at the annual meeting from the persons selected by the Fellows.

(*e*.) The methods of selection in subclause (*b*) and of the election in sub-clause (*d*) shall be determined by the Board of Governors.

(*f*.) The official abbreviation of the title "Fellow of the New Zealand Institute" shall be "F.N.Z.Inst."

Additional Regulation adopted by Board of Governors on 30th January, 1923, and published in the New Zealand Gazette *of 28th May, 1925.*

26A. The consent of the candidate must be obtained in writing.

The information regarding each candidate shall be condensed to one foolscap sheet of typewritten matter.

When a candidate is proposed by more than one society it shall be sufficient to circulate to voters the information supplied by one society.

Subsection (*e*) shall be rescinded, and the following inserted:

***Method of Selection in Subclause* (b) *and of Election in Subclause* (d)**

Names of Candidates, in Alphabetical Order.	X
APPLE, CHARLES	
BROWN, JOHN	
SMITH, JAMES	

There are vacancies to be filled. Place a cross in the column marked X against the name of each candidate for whom you wish to vote. The vote will be invalid if—

(*a.*) More than the required number is voted for on the paper:

(*b*) The voter signs the voting-paper:

(*c.*) The voting-paper is not returned on the date announced.

AMENDMENT TO REGULATIONS.

Regulation 5 (*a*) of the regulations published in the *New Zealand Gazette* on the 14th July, 1904, is hereby amended to read:—

"(*a.*) The publications of the Institute shall consist of—

" (1.) Such current abstract of the proceedings of the societies for the time being incorporated with the Institute as the Board of Governors deems desirable;

" (2.) And of transactions comprising papers read before the incorporated societies or any general meeting of the New Zealand Institute (subject, however, to selection as hereinafter mentioned), and of such other matter as the Board of Governors shall from time to time for special reasons in each case determine to publish, to be intituled *Transactions of the New Zealand Institute.*"

ADDITIONAL REGULATIONS.

The following additional regulations, made at various times by the Board of Governors under the New Zealand Institute Act, 1908, were adopted at a general meeting of the Board held on the 30th January, 1923, and published in the *New Zealand Gazette* of the 28th May, 1925.

BOARD OF GOVERNORS.

Members of the Board of Governors shall not hold any paid office under the Board.

GENERAL REGULATIONS.

The President shall be *ex officio* a member of all committees.

The Hon. Editor shall be convener of the Publications Committee.

The seal of the old Institute bearing the date of establishment as 1867 shall be adopted as the seal of the New Zealand Institute reconstituted by the New Zealand Institute Act, 1903, and continued by the New Zealand Institute Act, 1908.

An abstract of all business transacted at each meeting of the Standing Committee shall be prepared and communicated to all members of the Board after each meeting.

The quorum of the Standing Committee meetings shall be four.

Endowment Fund.

A fund to be called an "Endowment Fund" shall be set up, the interest on which for any year may be spent for purposes of the Institute, but the capital may not be spent.

All interest accruing from moneys deposited in the Institute's General Account in the Post Office Savings-bank shall be credited to the Endowment Fund, unless otherwise allocated by the Board at the annual meeting at which the amount of the annual interest is reported.

Trust Accounts.

Trust-moneys — namely, the Carter, Hector, Hutton, and Hamilton Funds—shall, when deposited in the Post Office Savings-bank, be placed in separate accounts for each trust.

REGULATIONS FOR ADMINISTERING THE GOVERNMENT RESEARCH GRANT.*

All grants shall be subject to the following conditions, and each grantee shall be duly informed of these conditions:—

1. All instruments, specimens, objects, or materials of permanent value, whether purchased or obtained out of or by means of the grant, or supplied from among those at the disposal of the Institute, are to be regarded, unless the Research Grants Committee decide otherwise, as the property of the Institute, and are to be returned by the grantee, for disposal according to the orders of the committee, at the conclusion of his research, or at such other time as the committee may determine.

2. Every one receiving a grant shall furnish to the Research Grants Committee, on or before the 1st January following upon the allotment of the grant, a report (or, if the object of the grant be not attained, an interim report, to be renewed at the same date in each subsequent year until a final report can be furnished or the committee dispense with further reports), containing (*a*) a brief statement showing the results arrived at or the stage which the inquiry has reached; (*b*) a general statement of the expenditure incurred, accompanied, as far as is possible, with vouchers; (*c*) a list of the instruments, specimens, objects, or materials purchased or obtained out of the grant, or supplied by the committee, which are at present in his possession; and (d) reference to any transactions, journals, or other publications in which results of the research have been printed. In the event of the grantee failing to send in within three months of the said 1st January a report satisfactory to the committee he may be required, on resolution of the Board of Governors, to return the whole of the sum allotted to him.

3. Where a grant is made to two or more persons acting as a committee for the purpose of carrying out some research, one member

---

*In addition to these regulations the Standing Committee is also bound by certain resolutions which appear on page 536 of volume 49, *Trans. N.Z. Inst.*, and which grantees are also bound to observe.

of the said committee shall assume the responsibility of furnishing the report and receiving and disbursing the money.

4. Papers in which results are published that have been obtained through aid furnished by the Government grant should contain an acknowledgment of that fact.

5. Every grantee shall, before any of the grant is paid to him, be required to sign an engagement that he is prepared to carry out the general conditions applicable to all grants, as well as any conditions which may be attached to his particular grant.

6. In cases where specimens or preparations of permanent value are obtained through a grant the committee shall, as far as possible, direct that such specimens shall be deposited in a museum or University college within the province where the specimens or material were obtained, or in which the grantee has worked. The acknowledgment of the receipt of the specimens by such institution shall fully satisfy the claims of the Institute.

7. In cases where, after completion of a research, the committee directs that any instrument or apparatus obtained by means of the grant shall be deposited in an institution of higher learning, such deposit shall be subject to an annual report from the institution in question as to the condition of the instrument or apparatus, and as to the use that has been made of it.

Additional Regulations adopted by Board of Governors on 30th January, 1923, and published in the New Zealand Gazette *of 28th May, 1925.*

8. Grants shall be given preferentially to investigations which appear to have an economic bearing; purely scientific investigations to be by no means excluded. When the research is one that leads to a direct economic advance the Government shall reserve to itself the right of patenting the discovery and of rewarding the discoverer, but it is to be understood that grants from the research-grant vote are not in the nature of a reward or a prize, but for out-of-pocket expenses incurred by the research worker, including salary or endowment of assistant, but not salary for the grantee himself. Plants, books, apparatus, chemicals, &c., purchased for applicants are to remain the property of the Institute, and eventually to form a loan collection of apparatus in the manner now practised by the Royal Society of London.

First method of initiating researches: Applications shall be invited for grants in aid of research to be specified by applicants.

Second method of initiating researches: The Governors of the Institute shall suggest from time to time subjects the investigation of which is desirable, and ask capable investigators to undertake such researches, the Institute paying for apparatus, material, and working-expenses, including assistance.

9. All applications for grants shall come through some incorporated society.

10. In the case of a refusal to recommend a grant, the Standing Committee shall not give any reasons for its refusal, unless such reason is stated in the minutes of the Standing Committee's meeting.

Research Grants made during 1927 and 1928.

Through the Auckland Institute:

Mosquito Control Committee, £300 and £100 for continuation of its work.

Mr. A. E. Brookes, £40, for study of the Coleoptera of the Islands off the Auckland Coast.

Through the Wellington Philosophical Society:

Professor D. C. H. Florance, £38 for research on Oscillation Crystals and Supersonic Waves.

Dr. G. H. Uttley, £35 for micrographic appartus for research on Bryozoa.

Through the Philosophical Institute of Canterbury.

Mr. E. W. Bennett, £200 for a Natural History Survey of Lake Forsyth.

Dr. C. Coleridge Farr, £150 for continuation of Research on Helium.

Mr. G. Jobberns, £25 for completion of work on Correlation of Shore Platforms on the North East Coast of the South Island.

Professor R. Speight, £150 for Geological Report on Mt. Somers District.

Dr. H. G. Denham, £75 for research on Essential Oil of Pinus Insignus.

Through the Otago Institute:

Dr. J. K. H. Inglis, £10 for continuation of research of Essential Oils of New Zealand Plants.

Mr. F. J. Turner, £100 for Geological Expedition to Red Hills.

Through the Nelson Institute:

Dr. K. M. Curtis, 50 for Investigation into Diseases of Tomatoes.

Dr. K. M. Curtis, 50 for Control of Black Rot in Hops.

Mr. A. Philpott, £40 for collecting specimens of Lepidoptera of Mt. Cook District.

Through the Manawatu Philosophical Society:

Dr. G. H. Cunningham, £25 for Mycological Survey of the Tongariro National Park.

Messrs. Wild and Zotov, £10 for research on Sexuality of New Zealand Coprosmas.

BOARD OF SCIENCE AND ART.

From the Science and Art Act, 1913, No. 22.

8. (1.) There shall be a Board styled "The Board of Science and Art," consisting of—

The Minister of Internal Affairs.

The Director of the Dominion Museum:

The President of the New Zealand Institute:—

Five persons to be appointed by the Governor-General in Council, each of whom shall hold office for three years from the date of his appointment.

(2.) The Board shall sit in the City of Wellington at such times and places as shall be appointed from time to time by the Minister.

(3.) Three of the members shall form a quorum.

(4.) At all meetings of the Board the Minister, if present, shall be the Chairman, and in his absence some member of the Board appointed by him in writing shall be Chairman.

(5.) The Chairman shall have a deliberate vote, and in all cases of equality of votes shall have a casting-vote.

(6.) *The President of the New Zealand Institute may appoint in writing a deputy, being a Governor of the New Zealand Institute, to attend and act at any meeting of the Board in his place; and such deputy, while so attending, shall be deemed to be a member of the Board.*

TONGARIRO NATIONAL PARK BOARD.

From the Tongariro National Park Act, 1922, No. 31.

5. (1.) The park shall be controlled and managed by a Board constituted as hereinafter provided.

(2.) The Board shall be a body corporate under the name of the Tongariro National Park Board, with perpetual succession and a common seal, and shall be capable of holding real and personal property and of doing and suffering all that bodies corporate may lawfully do or suffer.

(3.) The Board shall consist of the following persons:—

(*a*) The Minister of Lands:
(*b*.) The paramount chief for the time being of the Ngatituwharetoa Tribe of the Native race if that chief is a lineal descendant of Te Heuheu Tukino, the donor of the Native land included in the area of the Tongariro National Park:
(*c*.) The Mayors of the cities of Auckland and Wellington.
(*d*.) The Warden of the Park:
(*e*.) The Under-Secretary of the Department of Lands and Survey:
(*f*.) The General Manager of the Department of Tourist and Health Resorts:
(*g*.) The Secretary of the State Forest Service:
(*h*.) *The President of the New Zealand Institute*:
(*i*.) Not more than four persons to be appointed in that behalf by the Governor-General in Council.

8. (1.) The first ordinary meeting of the Board shall be held at such time and place as the Minister appoints, and subsequent ordinary meetings shall be held at such times and places as the Board appoints.

(2.) Special meetings of the Board may be called at any time by the Chairman, and he shall call one whenever any three members so request in writing.

From the Tongariro National Park Amendment Act, 1927, No. 46.

Subsection three of section five of the principal Act is hereby amended by repealing paragraph (*h*) thereof, and substituting the following paragraph:—

"(*h*) One member to be appointed by the Board of Governors of the New Zealand Institute, who shall hold office for three years from the date of his appointment, or until the appointment of his successor, and shall be eligible for reappointment."

THE HUTTON MEMORIAL MEDAL AND RESEARCH FUND.

Declaration of Trust.

This deed, made the fifteenth day of February, one thousand nine hundred and nine (1909), between the New Zealand Institute of the one part, and the Public Trustee of the other part: Whereas the New Zealand Institute is possessed of a fund consisting now of the sum of five hundred and fifty-five pounds one shilling (£555 1s.), held for the purposes of the Hutton Memorial Medal and Research Fund on the terms of the rules and regulations made by the Governors of the said Institute, a copy whereof is hereto annexed: And whereas the said money has been transferred to the Public Trustee for the purposes of investment, and the Public Trustee now holds the same for such purposes, and it is expedient to declare the trusts upon which the same is held by the Public Trustee:

Now this deed witnesseth that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purposes upon trust from time to time to invest the same upon such securities as are lawful for the Public Trustee to invest on, and to hold the principal and income thereof for the purposes set out in the said rules hereto attached.

And it is hereby declared that it shall be lawful for the Public Trustee to pay all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed so to do by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year hereinbefore written.

Resolutions of Board of Governors.

Resolved by the Board of Governors of the New Zealand Institute that—

1. The funds placed in the hands of the Board by the committee of subscribers to the Hutton Memorial Fund be called "The Hutton Memorial Research Fund," in memory of the late Captain Frederick Wollaston Hutton, F.R.S. Such fund shall consist of the moneys subscribed and granted for the purpose of the Hutton Memorial, and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding £100 shall be expended in procuring a bronze medal to be known as "The Hutton Memorial Medal."

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as aforesaid as may be approved of by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund.

5. The Hutton Memorial Medal shall be awarded from time to time by the Board of Governors, in accordance with these regulations, to persons who have made some noticeable contribution in connection with the zoology, botany, or geology of New Zealand.

6. The Board shall make regulations setting out the manner in which the funds shall be administered. Such regulations shall conform to the terms of the trust.

7. The Board of Governors may, in the manner prescribed in the regulations, make grants from time to time from the accrued interest to persons or committees who require assistance in prosecuting researches in the zoology, botany, or geology of New Zealand.

8. There shall be published annually in the *Transactions of the New Zealand Institute* the regulations adopted by the Board as aforesaid, a list of the recipients of the Hutton Memorial Medal, a list of the persons to whom grants have been made during the previous year, and also, where possible, an abstract of researches made by them.

Resolution regarding Investment of Funds (see Clause 4 above) adopted by Board on 30th January, 1923, and published in New Zealand Gazette *of 28th May, 1925.*

That the fund known as the "Hutton Memorial Fund," consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given jointly to the Hon. Secretary and the Hon. Treasurer acting conjointly.

That until the Hutton Memorial Fund reaches the sum of £1,000 not less than 1 per cent. on the capital invested be added each year to the principal.

REGULATIONS UNDER WHICH THE HUTTON MEMORIAL MEDAL SHALL BE AWARDED AND THE RESEARCH FUND ADMINISTERED.

1. Unless in exceptional circumstances, the Hutton Memorial Medal shall be awarded not oftener than once in every three years; and in no case shall any medal be awarded unless, in the opinion of the Board, some contribution really deserving of the honour has been made.

2. The medal shall not be awarded for any research published previous to the 31st December, 1906.

3. The research for which the medal is awarded must have a distinct bearing on New Zealand zoology, botany, or geology.

4. The medal shall be awarded only to those who have received the greater part of their education in New Zealand or who have resided in New Zealand for not less than ten years.

5. Whenever possible, the medal shall be presented in some public manner.

6. The Board of Governors may, at any annual meeting, make grants from the accrued interest of the fund to any person, society, or committee for the encouragement of research in New Zealand zoology, botany, or geology.

7. Applications for such grants shall be made to the Board before the 30th September.

8. In making such grants the Board of Governors shall give preference to such persons as are defined in regulation 4.

9. The recipients of such grants shall report to the Board before the 31st December in the year following, showing in a general way how the grant has been expended and what progress has been made with the research.

10. The results of researches aided by grants from the fund shall, where possible, be published in New Zealand.

11. The Board of Governors may from time to time amend or alter the regulations, such amendments or alterations being in all cases in conformity with resolutions 1 to 4.

AWARD OF THE HUTTON MEMORIAL MEDAL.

1911. Professor W. B. Benham, D.Sc., F.R.S., University of Otago—For researches in New Zealand zoology.

1914. Dr. L. Cockayne, F.L.S., F.R.S.—For researches in the ecology of New Zealand plants.

1917. Professor P. Marshall, M.A., D.Sc.—For researches in New Zealand geology.

1920. Rev. John E. Holloway, D.Sc.—For researches in New Zealand pteridophytic botany.

1923. J. Allan Thomson, M.A., D.Sc., F.G.S., F.N.Z.Inst.—For researches in geology.

1926. Charles Chilton, M.A., D.Sc., F.L.S., C.M.Z.S., F.N.Z.Inst. —For his continuous researches on the Amphipodous Crustacea of the Southern Hemisphere.

Grant from the Hutton Memorial Research Fund.

1919. Miss M. K. Mestayer £10, for work on the New Zealand Mollusca.

1923. Professor P. Marshall, M.A., D.Sc., F.N.Z.Inst.—£40, for study of Upper Cretaceous ammonites of New Zealand.

1927. Miss M. K. Mestayer £30, for research on Brachiopoda and Mollusca.

1928. Dr. C. Chilton £50, for research on New Zealand and Antarctic Crustacea.

—— Mr. J. H. Findlay £10, for research on New Zealand Mollusca.

HECTOR MEMORIAL RESEARCH FUND.

Declaration of Trust.

This deed, made the thirty-first day of July, one thousand nine hundred and fourteen, between the New Zealand Institute, a body corporate duly incorporated by the New Zealand Institute Act, 1908, of the one part, and the Public Trustee of the other part; Whereas by a declaration of trust dated the twenty-seventh day of January, one thousand nine hundred and twelve, after reciting that the New Zealand Institute was possessed of a fund consisting of the sum of £1,045 10s. 2d., held for the purposes of the Hector Memorial Research Fund on the terms of the rules and regulations therein mentioned, which said moneys had been handed to the Public Trustee for investment, it was declared (*inter alia*) that the Public Trustee should hold the said moneys and all other moneys which should be handed to him by the said Governors of the Institute for the same purpose upon trust from time to time, to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations in the said deed set forth: And whereas the said rules and regulations have been amended by the Governors of the New Zealand Institute, and as amended are hereinafter set forth: And whereas it is expedient to declare that the said moneys are held by the Public Trustee upon the trusts declared by the said deed of trust and for the purposes set forth in the said rules and regulations as amended as aforesaid.

Now this deed witnesseth and it is hereby declared that the Public Trustee shall hold the said moneys and all other moneys which shall be handed to him by the said Governors for the same purpose upon trust from time to time to invest the same in the common fund of the Public Trust Office, and to hold the principal and income thereof for the purposes set out in the said rules and regulations hereinafter set forth:

And it is hereby declared that it shall be lawful for the Public Trustee to pay, and he shall pay, all or any of the said moneys, both principal and interest, to the Treasurer of the said New Zealand Institute upon being directed to do so by a resolution of the Governors of the said Institute, and a letter signed by the Secretary of the said Institute enclosing a copy of such resolution certified by him and by the President as correct shall be sufficient evidence to the Public

Trustee of the due passing of such resolution: And upon receipt of such letter and copy the receipt of the Treasurer for the time being of the said Institute shall be a sufficient discharge to the Public Trustee: And in no case shall the Public Trustee be concerned to inquire into the administration of the said moneys by the Governors of the said Institute.

As witness the seals of the said parties hereto, the day and year first hereinbefore written.

Rules and Regulations made by the Governors of the New Zealand Institute in relation to the Hector Memorial Research Fund.

1. The funds placed in the hands of the Board by the Wellington Hector Memorial Committee shall be called "The Hector Memorial Research Fund," in memory of the late Sir James Hector, K.C.M.G., F.R.S. The object of such fund shall be the encouragement of scientific research in New Zealand, and such fund shall consist of the moneys subscribed and granted for the purpose of the memorial and all other funds which may be given or granted for the same purpose.

2. The funds shall be vested in the Institute. The Board of Governors of the said Institute shall have the control of the said moneys, and may invest the same upon any securities proper for trust-moneys.

3. A sum not exceeding one hundred pounds (£100) shall be expended in procuring a bronze medal, to be known as the Hector Memorial Medal.

4. The fund, or such part thereof as shall not be used as aforesaid, shall be invested in such securities as may be approved by the Board of Governors, and the interest arising from such investment shall be used for the furtherance of the objects of the fund by providing thereout a prize for the encouragement of such scientific research in New Zealand of such amount as the Board of Governors shall from time to time determine.

5. The Hector Memorial Medal and prize shall be awarded annually by the Board of Governors.

6. The prize and medal shall be awarded by rotation for the following subjects, namely—(1) Botany, (2) chemistry, (3) ethnology, (4) geology, (5) physics (including mathematics and astronomy), (6) zoology (including animal physiology).

In each year the medal and prize shall be awarded to that investigator who, working within the Dominion of New Zealand, shall in the opinion of the Board of Governors have done most towards the advancement of that branch of science to which the medal and prize are in such year allotted.

7. Whenever possible the medal shall be presented in some public manner.

Resolution regarding Investment of Funds (see Clause 4 above) adopted by Board on 30th January, 1923, and published in New Zealand Gazette *of 28th May, 1925.*

That the fund known as the "Hector Memorial Fund," consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such

securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given jointly to the Hon. Secretary and the Hon. Treasurer acting conjointly.

Award of the Hector Memorial Research Fund.

1912. L. Cockayne, Ph.D., F.L.S., F.R.S.—For researches in New Zealand botany.
1913. T. H. Easterfield, M.A., Ph.D.—For researches in chemistry.
1914. Elsdon Best—For researches in New Zealand ethnology.
1915. P. Marshall, M.A., D.Sc., F.G.S.—For researches in New Zealand geology.
1916. Sir Ernest Rutherford, F.R.S.—For researches in physics.
1917. Charles Chilton, M.A., D.Sc., F.L.S., C.M.Z.S.—for researches in zoology.
1918. T. F. Cheeseman, F.L.S., F.Z.S.—For researches in New Zealand systematic botany.
1919. P. W. Robertson—For researches in chemistry.
1920. S. Percy Smith—For researches in New Zealand ethnology.
1921. R. Speight, M.A., M.Sc., F.G.S.—For work in New Zealand geology.
1922. C. Coleridge Farr, D.Sc.—For research in physical science, and more particularly work in connection with the magnetic survey of New Zealand.
1923. G. V. Hudson, F.E.S., F.N.Z.Inst.—For researches in New Zealand entomology.
1924. D. Petrie, M.A., F.N.Z.Inst.—For researches in New Zealand botany.
1925. B. C. Aston, F.I.C., F.N.Z.Inst.—For the investigation of New Zealand chemical problems.
1926. H. D. Skinner, B.A.—For research in Ethnology.
1927. D. M. Y. Sommerville, M.A., D.Sc., F.N.Z.Inst.—For his general mathematical work and particularly for his investigations in Non-Euclidean Geometry.

HAMILTON MEMORIAL FUND.

1. The fund placed in the hands of the Board by the Wellington Philosophical Society shall be called the "Hamilton Memorial Fund" in memory of the late Augustus Hamilton, Esq. Such fund shall consist of the moneys subscribed and granted for the purpose of the memorial and all other funds which may be given or granted for the same purpose.

2. The fund shall be vested in the Institute. The Board of Governors of the Institute shall have the control thereof, and shall invest the same in any securities proper for trust-moneys.

3. The memorial shall be a prize, to be called the "Hamilton Memorial Prize," the object of which shall be the encouragement of beginners in pure scientific research in New Zealand.

4. The prize shall be awarded at intervals of not less than three years by the Governors assembled in annual meeting, but in no case

shall an award be made unless in the opinion of the Governors some contribution deserving the honour has been made. The first award shall be made at the annual meeting of the Governors in 1923.

5. The prize shall be awarded for original pure scientific research-work, carried out in New Zealand or in the Islands off the South Pacific Ocean, which has been published within the five years preceding the first day of July prior to the annual meeting at which the award is made. Such publication may consist of one or more papers, and shall include the first investigation published by the author. No candidate shall be eligible for the prize who prior to such period of five years has published the result of any scientific investigation.

6. The prize shall consist of money. Until the principal of the fund amounts to £100, one-half of the interest shall be added annually to the principal and the other half shall be applied in payment of the prize. So soon as the said principal amounts to £100 the whole of the interest thereon shall be applied in payment of the prize, in each case after the payment of all expenses necessarily incurred by the Governors in the investment and administration of the said fund and award of the said prize.

7. A candidate for the prize shall send to the Hon. Secretary of the New Zealand Institute, on or before the 30th day of June preceding the date of the annual meeting at which the award is to be made, an intimation of his candidature, together with at least two copies of each publication on which his application is based.

8. Whenever possible the prize shall be presented in some public manner.

Award of the Hamilton Memorial Prize.

1923. J. G. Myers, M.Sc.
1926. H. J. Finlay, M.Sc.; J. Marwick, M.A., D.Sc.

THE CARTER BEQUEST.

Extracts from the Will of Charles Rooking Carter.

This is the last will and testament of me, Charles Rooking Carter, of Wellington, in the Colony of New Zealand, gentleman.

I revoke all wills and testamentary dispositions heretofore made by me, and declare this to be my last will and testament.

* * * * *

I give to the Colonial Museum in Wellington the large framed photographs of the members of the General Assembly in the House of Representatives in the year 1860, and the framed pencil sketch of the old House of Commons, and the framed invitation-card to the Lord Mayor's dinner.

* * * * *

As regards the following books, of which I am the author, and which are now stored in three boxes—namely, (1) "The Life and Recollections of a New Zealand Colonist," (2) "A Historical Sketch of New Zealand Loans," and (3) "Round the World Leisurely"—I direct that my executor shall retain possession of the same for a period of seven years, commencing from the date of my death, and that at the end of such period my executor shall place the same in the hands of Messrs. Whitcombe and Tombs (Limited) or some other capable and responsible booksellers in the City of Wellington, for sale, and so that the same shall be sold at such a price as will yield

to my estate not less than six shillings per volume in respect of the first-named and second-named, and two shillings and sixpence in respect of the last-named works; and I further authorize my executor to sell and dispose of the copyright or right to reprint such works; and I direct that the moneys to be derived from the sale of such works and the privileges connected therewith shall be added to the sum provided for the purchase of a telescope as hereinafter mentioned.

I direct my executor to subscribe the sum of fifty pounds towards the erection of a suitable brick room in which to house the priceless collection of books on New Zealand some time since given by me to the Colonial Museum and the New Zealand Institute.

I give and devise unto the Public Trustee appointed under and in pursuance of an Act of the General Assembly of New Zealand intituled the Public Trust Office Act, 1894 (hereinafter called "my trustee"), all the rest, residue, and remainder of my property whatsoever and wheresoever situate, both real and personal, and whether in possession, reversion, expectancy, or remainder, upon trust, as to my freehold property at East Taratahi, containing by admeasurement two thousand one hundred and seventy-two acres, and being and comprising the whole of the land included in certificate of title, volume 51, folio 79, of the books of the District Land Registrar for the Registration District of Wellington, (save and except such part of the said land, being portion of the section numbered 117 in the Taratahi Plain Block, as is hereinafter devised to my trustee for the purposes hereinafter appearing), and direct that my trustee shall stand possessed of the same lands upon trust, to let and manage the same, and to pay and apply the rents and annual income in manner following, namely:—

* * * * *

And as to all the residue and remainder (if any) of the said net proceeds of the sale, conversion, and getting-in of my estate as aforesaid, my trustee shall transfer the same to the Governors for the time being of the New Zealand Institute at Wellington, to form the nucleus of a fund for the erection in or near Wellington aforesaid, and the endowment of a Professor and staff, of an Astronomic Observatory fitted with telescope and other suitable instruments for the public use and benefit of the colony, and in the hope that such fund may be augmented by gifts from private donors, and that the Observatory may be subsidized by the Colonial Government; and without imposing any duty or obligation in regard thereto I would indicate my wish that the telescope may be obtained from the factory of Sir H. Grubb, in Dublin, Ireland.

* * * * *

Resolution regarding Investment of Funds (see Clause 4 above), adopted by Board on 30th January, 1923, and published in the New Zealand Gazette, *of 28th May, 1925.*

That the fund known as the "Carter Bequest," consisting of the principal originally placed by the Board of Governors in the hands of the Public Trustee, together with the interest accrued thereon, be withdrawn from the Public Trustee and reinvested in such securities as provided for by legislation covering trust-moneys, power to arrange details and to act being given jointly to the Hon. Secretary and the Hon. Treasurer acting conjointly.

NEW ZEALAND INSTITUTE, 1928.

ESTABLISHED UNDER AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND INTITULED THE NEW ZEALAND INSTITUTE ACT, 1867; RECONSTITUTED BY AN ACT OF THE GENERAL ASSEMBLY OF NEW ZEALAND UNDER THE NEW ZEALAND INSTITUTE ACT, 1903, AND CONTINUED BY THE NEW ZEALAND INSTITUTE ACT, 1908.

BOARD OF GOVERNORS.

EX OFFICIO.

His Excellency the Governor-General.
The Hon. the Minister of Internal Affairs.

NOMINATED BY THE GOVERNMENT.

Dr. Charles Chilton, M.A., F.L.S., C.M.Z.S., F.N.Z.Inst. (reappointed December, 1926); Dr. Leonard Cockayne, F.R.S., F.L.S., F.N.Z. Inst. (reappointed December, 1926). Mr B. C. Aston, F.I.C., F.C.S. F.N.Z.Inst. (reappointed December, 1927); Dr. J. Allan Thomson, F.G.S., F.N.Z.Inst. (reappointed December, 1927).

ELECTED BY AFFILIATED SOCIETIES, 1927.

Wellington Philosophical Society	Mr. G. V. Hudson, F.E.S., F.N.Z.Inst. Professor H. B. Kirk, M.A., F.N.Z.Inst.
Auckland Institute	Professor H. W. Segar, M.A., Ph.D., F.N.Z.Inst. Professor F. P. Worley, D.Sc.
Philosophical Institute of Canterbury	Professor C. Coleridge Farr, D.Sc., F.P.S.L., F.N.Z.Inst. Mr. A. M. Wright, A.I.C., F.C.S.
Otago Institute	Hon. G. M. Thomson, F.L.S., F.N.Z.Inst., M.L.C. Professor J. Park, F.G.S., F.N.Z.Inst.
Hawke's Bay Philosophical Institute	Mr. H. Hill, B.A., F.G.S.
Nelson Institute	Professor T. H. Easterfield, M.A., Ph.D., F.I.C., F.N.Z.-Inst.
Manawatu Philosophical Society	Mr. M. A. Eliott.

OFFICERS FOR THE YEAR 1928.

PRESIDENT: Dr. J. Allan Thomson, F.G.S., F.N.Z.Inst.

HON. TREASURER: Mr. M. A. Eliott.

HON. EDITOR: Mr. Johannes C. Andersen, F.N.Z.Inst.

HON. LIBRARIAN: Professor D. M. Y. Sommerville, M.A., D.Sc., F.R.S.E., F.N.Z.Inst.

HON. RETURNING OFFICER: Professor H. W. Segar, M.A., Ph.D., F.N.Z.Inst.

HON. SECRETARY: Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst.

AFFILIATED SOCIETIES, 1927-28.

Name of Society.	Secretary's Name and Address.	Date of Affiliation.
Wellington Philosophical Society	Mr. W. J. Phillipps, Dominion Museum, Wellington	10th June, 1868.
Auckland Institute	Mr. G. Archey, Auckland Institute and Museum, Auckland	10th June, 1868.
Philosophical Institute of Canterbury	Mr. R. O. Page, 59 May's Road, Christchurch.	22nd October, 1868.
Otago Institute	Mr. F. H. Turner, Geology Department, Otago University, Dunedin.	18th October, 1869.
Hawkes Bay Philosophical Institute	Mr. C. F. H. Pollock, P. O. Box 301, Napier.	31st March, 1875.
Nelson Institute	Mrs. Margaret Graham, Nelson	20th December, 1883
Manawatu Philosophical Society	Mr. J. C. Merton, Solicitor, P.O. Box 346, Palmerston North.	6th January, 1905.

FORMER MANAGER AND EDITOR.

[UNDER THE NEW ZEALAND INSTITUTE ACT, 1867.]

1867-1903.—Hector, Sir James, M.D., K.C.M.G., F.R.S.

PAST PRESIDENTS.

1903-4.—Hutton, Captain Frederick Wollaston, F.R.S.
1905-6.—Hector, Sir James, M.D., K.C.M.G., F.R.S.
1907-8.—Thomson, George Malcolm, F.L.S.
1909-10.—Hamilton, A.
1911-12.—Cheeseman, T. F., F.L.S., F.Z.S.
1913-14.—Chilton, C., M.A., D.Sc., LL.D., F.L.S., C.M.Z.S.
1915.— Petrie, D., M.A., Ph.D.
1916-17.—Benham, W. B., M.A., D.Sc., F.Z.S., F.R.S.
1918-19.—Cockayne, L., Ph.D., F.R.S., F.L.S., F.N.Z.Inst.
1920-21.—Easterfield, T. H., M.A., Ph.D., F.N.Z.Inst.
1922-23.—Kirk, H. B., M.A., F.N.Z.Inst.
1924-25.—Dr. P. Marshall, M.A., F.G.S., F.N.Z.Inst.
1926-27.—Mr. B. C. Aston, F.I.C., F.C.S., F.N.Z.Inst.

HONORARY MEMBERS.

	Elected
Armstrong, Professor H. E., F.R.S., Ph.D., LL.D. Professor Emeritus City and Guilds of London Institute, 55 Granville Park, Lewisham, London, S.E.	1927
Bragg, Professor W. H., F.R.S., Royal Institution, 21 Albemarle St., London, W.1	1923
Chree, Charles, M.A., D.Sc., LL.D., F.R.S., Kew Observatory, London	1924
Curie, Madame Marie, Institut du Radium, Laboratoire Curie, 1 Rue Pierre-Curie, Paris (5e)	1927
David, Professor T. Edgeworth, F.RS,, C.M.G., Sydney University	1904
Davis, Professor W. Morris, Museum, Cambridge, Mass., U.S.A.	1913
Diels, Professor L., Ph.D., University of Berlin, Botanisches Museum, Berlin	1907
Einstein, Professor Albert, University of Berlin, Germany	1924
Fraser, Sir J. G., D.C.L., Trinity College, Cambridge	1920
Goebel, Professor Dr. Carl von, University of Munich	1901
Gregory, Professor J. W., D.Sc., F.R.S., F.G.S., 4 Park Quadrant, Glasgow W.	1920
Haddon, Dr. A. C., F.R.S., 3 Cranmer Road, Cambridge	1925
Haldane, J. S., M.A., M.D., LL.D., F.R.S., Cherwell, Oxford	1928
Hall, Sir A. D., M.A., K.C.B., F.R.S., Ministry of Agriculture, London	1920
Hill, Dr. A. W., F.R.S., Director Royal Botanic Gardens, Kew	1928
Jaggar, Dr. T. A., Director of Volcanological Observatory, Volcano House, P.O. Hawaii	1927
Lotsy, Dr. J. P., Velp, near Arnhem, Holland	1927
Masson, Sir D. Orme, K.B.E., M.A., D.Sc., F.R.S., 14 William Street, South Yarra, Melbourne	1928
Mawson, Sir Douglas, B.E., D.Sc., The University, Box 498, Adelaide	1920
Mellor, Joseph William, D.Sc. (N.Z.), Sandon House, Regent Street, Stoke-on-Trent, England	1919
Meyrick, E., B.A., F.R.S., Thornhanger, Marlborough, Wilts	1907
Mortensen, Theodor, Ph.D., Director of the Dept. of Invertebrates of the Zoological Museum, Copenhagen	1927
Russell, Sir John, D.Sc., F.R.S., Director of Rothamsted Experiment Station, Harpenden	1928
Rutherford, Professor Sir E., D.Sc., F.R.S., F.N.Z.Inst., Newnham Cottage, Queen's Road, Cambridge, England	1904
Seward, Professor A. C., Sc.D., F.R.S., Botany School, Cambridge	1928
Thiselton-Dyer, Sir W. T., K.C.M.G., C.I.E., LL.D., M.A., F.R.S., Witcombe, Gloucester, England	1894
Thomson, Professor J. Arthur, M.A., LL.D., Natural History Department, University of Aberdeen	1928
Woods, Henry, M.A., F.R.S., F.G.S., Sedgwick Museum, Cambridge	1920

FORMER HONORARY MEMBERS.

	Elected
Agardh, Dr. J. G.	1900
Agassiz, Professor Louis	1870
Arber, E. A. Newell, M.A., Sc.D., F.G.S., F.L.S.	1914
Avebury, Lord, P.C., F.R.S.	1900
Baird, Professor Spencer F.	1877
Balfour, Professor I. Bayley, F.R.S.	1914
Bateson, Professor W., F.R.S.	1915
Beddard, F. E., D.Sc., F.R.S., Zoological Society, London	1906
Beneden, Professor J. P. van	1888
Berggren, Dr. S.	1876
Bowen, Sir George Ferguson, G.C.M.G.	1873
Brady, G. S., D.Sc., F.R.S.	1906
Bruce, Dr. W. S.	1910
Carpenter, Dr. W. B., C.B., F.R.S.	1883
Clarke, Rev. W. B., M.A., F.R.S.	1876
Codrington, Rev. R. H., D.D.	1894
Darwin, Charles, M.A., F.R.S.	1871
Darwin, Sir George, F.R.S.	1909
Davis, J. W., F.G.S., F.L.S.	1891
Dendy, Dr. A., F.R.S., King's College, University of London, England	1907
Drury, Captain Byron, R.N.	1870
Ellery, Robert L. J., F.R.S.	1883
Etheridge, Professor R., F.R.S.	1876
Ettingshausen, Baron von	1888
Eve, H. W., M.A.	1901
Filhol, Dr. H.	1875
Finsch, Professor Otto, Ph.D.	1870
Flower, Professor W. H., F.R.S.	1870
Garrod, Professor A. H., F.R.S.	1878
Goodale, Professor G. L., M.D., LL.D	1891
Gray, J. E., Ph.D., F.R.S.	1871
Gray, Professor Asa	1885
Grey, Sir George, K.C.B.	1872
Günther, A., M.D., M.A., Ph.D., F.R.S.	1873
Haswell, Professor W. A., F.R.S., Mimihau, Woollahra Point, Sydney	1914
Hedley, Charles, F.L.S.,	1924
Hemsley, Dr. W. Botting, F.R.S., Kew Lodge, St. Peter's Road, Broadstairs, Kent, England	1913
Hochstetter, Dr. Ferdinand von	1870
Hooker, Sir J. D., G.C.S.I., C.B., M.D., F.R.S., O.M.	1870
Howes, G. B., LL.D., F.R.S.	1901
Huxley, Thomas H., LL.D., F.R.S.	1872
Klotz, Professor Otto J.	1903
Langley, S. P.	1896
Lindsay, W. Lauder, M.D., F.R.S.E.	1871
Liversidge, Professor A., M.A., F.R.S.	1890
Lydekker, Richard, F.R.S.	1896
Lyell, Sir Charles, Bart., D.C.L., F.R.S.	1873
Massart, Professor Jean	1916
McCoy, Professor Sir F., K.C.M.G., D.Sc., F.R.S.	1888
McLachlan, Robert, F.L.S.	1874
Massee, George, F.L.S., F.R.M.S.	1900
Milne, J., F.R.S.	1906
Mitten, William, F.R.S.	1895
The Most Noble the Marquis of Normanby, G.C.M.G.	1880
Mueller, Ferdinand von, M.D., F.R.S., C.M.G.	1870
Müller, Professor Max, F.R.S.	1878
Newton, Alfred, F.R.S.	1874
Nordstedt, Professor Otto, Ph.D.	1890
Owen, Professor Richard, F.R.S.	1870
Pickard - Cambridge, Rev. O., M.A., F.R.S., C.M.Z.S.	1873
Richards, Rear-Admiral G. H.	1870
Riley, Professor C. V.	1890
Rolleston, Professor G., M.D., F.R.S.	1875
Sars, Professor G. O.	1902
Sclater, P. L., M.A., Ph.D., F.R.S.	1875
Sharp, Dr. D.	1877
Sharp, Richard Bowdler, M.A., F.R.S.	1885
Stebbing, Rev. T. R. R., F.R.S.	1907
Stokes, Vice-Admiral J. L.	1872
Tenison-Woods, Rev. J. E., F.L.S.	1878
Thomson, Professor Wyville, F.R.S.	1874
Thomson, Sir William, F.R.S.	1883
Wallace, Sir A. R., F.R.S., O.M.	1885
Weld, Frederick A., C.M.G.	1877

FELLOWS OF THE NEW ZEALAND INSTITUTE.

Original Fellows.

(See *New Zealand Gazette*, 20th November, 1919.)

†Aston, Bernard Cracroft, F.I.C., F.C.S.
*‡Benham, Professor William Blaxland, M.A., D.Sc., F.R.S., F.Z.S.
†Best, Elsdon.
*†Cheeseman, Thomas Frederick, F.L.S., F.Z.S. §
*†‡Chilton, Professor Charles, M.A., D.Sc., LL.D., M.B., C.M., F.L.S., C.M.Z.S.
*†‡Cockayne, Leonard, Ph.D., F.R.S., F.L.S.
†Easterfield, Professor Thomas Hill, M.A., Ph.D., F.I.C., F.C.S.
†Farr, Professor Clinton Coleridge, D.Sc., F.P.S.L.
Hogben, George, C.M.G., M.A., F.G.S. §
†Hudson, George Vernon, F.E.S.
Kirk, Professor Harry Borrer, M.A.
†‡Marshall, Patrick, M.A., D.Sc., F.G.S., F.R.G.S., F.E.S.
*†Petrie, Donald, M.A., Ph.D. §
†Rutherford, Sir Ernest, Kt., F.R.S., D.Sc., Ph.D., LL.D.
Segar, Professor Hugh William, M.A.
†Smith, Stephenson Percy, F.R.G.S. §
†Speight, Robert, M. A., M.Sc., F.G.S.
Thomas, Professor Algernon Phillips Withiel, M.A., F.L.S.
*Thomson, Hon. George Malcolm, F.L.S., M.L.C.
†Thomson, James Allan, M.A., D.Sc., A.O.S.M., F.G.S.

Fellows elected, 1921.

Cotton, Charles Andrew, D.Sc., A.O.S.M., F.G.S.
Hilgendorf, Frederick William, B.A., D.Sc.
‡Holloway, Rev. John Ernest, L.Th., D.Sc.
Park, Professor James, M.Am.Inst.M.E., M.Inst.M.M., F.G.S.

Fellows elected, 1922.

Laing, Robert Malcolm, M.A., B.Sc.
Marsden, Ernest, D.Sc., F.R.A.S.
Morgan, Percy Gates, M.A., F.G.S., A.O.S.M.
Sommerville, Duncan McLaren Young, M.A., D.Sc., F.R.S.E.

Fellows elected, 1923.

Williams, Ven. Archdeacon Herbert William, M.A.
Andersen, Johannes Carl.

Fellows elected, 1924.

Smith, William Herbert Guthrie.
Tillyard, Robin John, M.A., D.Sc., Sc.D., F.L.S., F.E.S.

Fellows elected, 1925.

Brown, Professor J. Macmillan, M.A., LL.D.
Te Rangi Hiroa (P H. Buck), M.D., Ch.B. (N.Z.).

Fellows elected, 1926.

Benson, Professor W. N., B.A., D.Sc., F.G.S.
Maclaurin, J. S., D.Sc., F.C.S.

Fellows Elected 1927.

Oliver, W. R. B.
†Skinner, H. D., B.A.

Fellows Elected, 1928.

Allan, H. H., D.Sc., M.A., F.L.S.
Bartrum, J. A., M.Sc.

---

* Past President. † Hector Medallist. ‡ Hutton Medallist. § Deceased.

ORDINARY MEMBERS.

WELLINGTON PHILOSOPHICAL SOCIETY.

[* Life Members.]

Ackland, E. W., P.O. Box 928, Wellington.
Adams, C. E., D.Sc., A.I.A. (London), F.R.A.S., Dominion Observatory, Wellington.*
Adkin, G. L., Queen Street, Levin.
Andersen, Johannes C., F.N.Z.Inst., Alexander Turnbull Library, Bowen Street, Wellington.
Andrew, R. L., Dominion Laboratory, Wellington.
Aston, B. C., F.I.C., F.C.S., F.N.Z.Inst., Dominion Laboratory, Wellington.
Atkinson, E. H., 71 Fairlie Terrace, Kelburn.
Baker, A. J., Public Works Dept., Wellington.
Baillie, H., Public Library, Wellington.
Baldwin, E. S., 215 Lambton Quay, Wellington.
Balneavis, H. R. H., Parliament Buildings, Wellington.
Barnett, Dr. M., Dominion Laboratory.
Barwell, J. S., Akatore, Otago.
Bates, D. C., Meteorological Office, Wellington.
Bayne, J. A. C., Inspecting Engineer, Mines Department.
Beckett, Peter, Paraparaumu.
Bell, E. D., Featherston Street, Wellington.
Bell, Sir Francis, Featherston Street, Wellington.
Benham, A. H., 52 Watt Street, City.
Bennett, Francis, Queen Alexandra Street, Khandallah.
Berry, C. G. G., Railway Buildings, Wellington.
Best, Elsdon, F.N.Z.Inst., Alexander Turnbull Library, Bowen Street, Wellington.
Blair, David K., M.I.Mech.E., 9 Grey Street, Wellington.
Bollons, Capt. J., Marine Department.
Bradshaw, G. B., Box 863, Wellington.
Brandon, A. de B., B.A., Featherston Street, Wellington.
Brent, H. C., Laboratory, G.P.O., Wellington.
Bruce, E., 71 Fairlie Terrace, Wellington.
Callaghan, F. R., Dept. of Scientific Research, Wellington.
Castle, Miss A., Dominion Museum.
Chamberlin, T. Chamberlin, Crescent Road, Khandallah.
Christie, J. H., P.W.D., Kurow, Otago.
Cobeldick, W., F.R.G.S., Tourist Department, Rotorua.
Cockayne, A. H., Agriculture Department, Wellington.
Cockayne, L., Ph.D., F.L.S., F.R.S. F.N.Z.Inst., Ngaio, Wellington.
Cockroft, T., 111 Owen Street, Wellington.
Cook, C. W., Customs Dept., Wellington.
Cotton, C. A., D.Sc., F.G.S., F.N.Z.Inst., Victoria University College, Wellington.*
Coventry, Mrs. H., 22 Disley Street, Kelburn.
Crawford, A. D., Box 126, G.P.O., Wellington.
Croker, Mrs. Olive, 64 Derwent Street, Island Bay.
Cromb, J. B., C/o. Wellington Harbour Board.
Crust, A. G. C., Dominion Observatory, Kelburn.
Cull, J. E. L., B.Sc. in Eng. (Mech.), Public Works Department, Wellington.
Cumming, E., Land and Income Tax Department, Wellington.
Dalrymple, K. W., Parewanui, Bulls.
Darling, J., Kelburn.
Donovan, W., M.Sc., Dominion Laboratory, Wellington.
Dougall, Archibald, 9 Claremont Grove, Wellington.
Dyer, Miss M., Education Department, Wellington.
Dymock, E. R., F.I.A.N.Z., A.I.A.V., Box 193, Wellington.
Evans, Professor W. P., Kensington street, Wellington.
Exley, Lionel, Nat. Elect. Engineering Co.
Ferguson, William, M.A., M.Inst.C.E., M.I.Mech.E., Silverstream, Wellington.
Ferrar, H. T., M.A., F.G.S., Geological Survey Department, 156 The Terrace.*
Fletcher, Rev. H. J., The Manse, Normanby.
Florance, D. C. H., Professor, Victoria College, Wellington.
Forrester, J. H., Customs Department, Wellington.

Frost, C. A., care of Richardson, McCabe, and Co., Wellington.
Furkert, F. W., Assoc.M.Inst.C.E., Public Works Department, Wellington.
Garrow, Professor J. M. E., B.A., LL.B., Victoria University College, Wellington.*
Gavey, A., Public Works Dept., Wellington.
Gibbs, A. E., M.I.E.E., Assistant Telegraph Engineer, G.P.O., Wellington.
Gibbs, Dr. H. E., 240 Willis Street, Wellington.
Gifford, A. C., M.A., F.R.A.S., 6 Shannon Street, Wellington.*
Gill, D. A., Path. Lab., Wallaceville.
Good, F. W., Main-superintendent, Electric Light Department, Harris Street, Wellington.
Grange, L. I., 38 The Terrace, Wellington.
Greenshields, F. S., 9 Glen Road, Kelburn.
Grimmett, R. E. R., Agricultural Laboratory, Wellington.
Hamilton, H., A.O.S.M., Director Maori School of Arts and Crafts, Rotorua.
Hardcastle, H., *Evening Post*, Wellington.
Harty, Dr. G. W., 14 Hill Street, City.
Hastie, Miss J. A., care of Street and Co., 30 Cornhill, London, E.C.*
Hayes, Capt. L., Marine Dept., Wellington.
Heays, H. C., Head Office, P.W.D., Wellington.
Hector, C. Monro, M.D., B.Sc., F.R.A.S., Hobson Street, Wellington.
Hefford, A E., M.Sc., Fisheries Expert, Marine Dept.
Helyer, Miss E., 13 Tonks Grove, Wellington.
Henderson, J., M.A., D.Sc., B.Sc. in Eng. (Metall.), Geological Survey Department, Wellington.
Henry, E. O., Head Office, P.W.D., Wellington.
Hislop, J., Internal Affairs Department, Wellington.
Hodson, W. H., 40 Pirie Street, Wellington.
Holloway A. G. P., 17 Macdonald Cres., Wellington.
Holmes, R. W., M.Inst.C.E., Burnell Avenue, Wellington.
Hooper, Captain G. S., Marine Department, Wellington.
Hooper, R. H., 6 St. John Street, Wellington.
Hopkirk, C. S., Pathological Lab., Wallaceville.
Hudson, G. V., F.E.S., F.N.Z.Inst., Hill View, Karori.

Hunt, A. Leigh, Dominion Farmers' Institute, Wellington.
Hurley, J. A., Bacteriological Laboratory, Newtown.
Izatt, A., Woodland Rd., Johnsonville.
Jack, J. W., 170 Featherston Street, Wellington.
Jackson, Miss, B.A., Wellington Girls' College.
Jacobson, N. R., Training College, Kelburn.
Joiner, W. A., Dominion Laboratory, Wellington.
Jones, A. Morris, 47 Upland Road, Kelburn.
Jones, J. A., Chief Engineer, N.Z. Railways, Wellington.
Jones, Llewellyn, 57 Creswick Terrace, Wellington.
Joyce, Miss, Training College, Kelburn.
Kean, A., Tourist Dept., Wairoa.
Kerr, W. J., National Bank, Grey Street, Wellington.
Kirk, Professor H. B., M.A., F.N.Z.Inst., Victoria University College, Wellington.
Kissell, F. T. M., Public Works Department, Wellington.
La Trobe, W. S., M.A., Hamilton Road, Karori.
Lauchlan, G., Electrical Engineer, Harris Street, Wellington.
Lawrence, G. A., Johnsonville.
Leighton, F. T., Dominion Laboratory.
Levi, P., M.A., care of Wilford and Levi, 15 Stout Street, Wellington.
Levy, E. Bruce, 71 Fairlie Terrace, Kelburn.
Lindsay, C., Dominion Museum, Wellington.
Lomas, E. K., M.A., M.Sc., Training College, Wellington.
Lomax, Major H. A., 288 Somme Parade, Aramoho, Wanganui.
Luke, Sir John P., C.M.G., M.P., "Pendennis," Burnell Avenue, Wellington.
Luscombe, A., 59 Palliser Road, Roseneath.
McDermott, J., Dist. Engineer, P. and T. Dept., Wellington.
McInnes, E. H., Engineer, 160 Lambton Quay, Wellington.
McKay, W. A., Dominion Museum, Wellington.
McKenzie, C. J., Public Works Department, Wellington.
Maclaurin, J. S., D.Sc., F.C.S., Dominion Laboratory, Wellington.
MacLean, F. W., M.Inst.C.E., Chief Engineer, Head Office, Railway Department, Wellington.
McSherry, Harry, Box 49, Pahiatua.
Malcolm, J., P.O. Box 863, Wellington.

Marchbanks, J., Harbour Board, Wellington.
Marsden, E., D.Sc., F.N.Z. Inst., Director of Scientific and Industrial Research.
Marshall, Dr. P., c/o Main Highways Board, Wellington.
Marwick, J., D.Sc., Geological Survey, The Terrace, Wellington.
Maskell, F. G., Victoria University College, Wellington.
Matheson, W. B., Tiratahi, Eketahuna.
Maxwell, E., Marumarunui, Opunake.
Maxwell, J. P., M.Inst.C.E., 145 Dixon Street, Wellington.
Mestayer, Miss M., Sydney Street, Wellington.
Miles, P. C. V. R., Room 45, G.P.O., Wellington.
Millar, H. M., Public Works Department, Wellington.
Moore, G., Eparaima, via Masterton.
Moore, W., Lancelot, Bank Chambers, Lambton Quay, Wellington.
Moorhouse, W. H. Sefton, 134 Dixon Street, Wellington.
Morice, J. M., B.Sc., Town Hall, Wellington.
Morrison, J. C., Box 413, G.P.O., Wellington.
Morton, W., Hydro-electric Board, Public Works Department, Wellington.
Muir, A. G., Dist. Office, P.W.D., Auckland.
Mundy, R., Kings Court, Ohakune.
Myers, J. G., Imperial Bureau of Entomology, 41 Queen's Gate, London, S.W.7

Neill, J. C., 251 The Terrace, Wellington.
Neill, W. T., Lands and Survey Department, Government Buildings, Wellington.
Newnham, W. L., Public Works Department, Wellington.
Newton, A., care of Newton Engineering Company, Wellington.
Ngata, Hon. Sir A. T., Parliament Buildings, Wellington.
Norris, E. T., M.A., Registrar, University of New Zealand, Wellington.
Northcroft, E. T., Victoria University College, Kelburn.

Oliver, W. R. B., F.L.S., F.Z.S., Dominion Museum, Wellington.*
Ongley, M., M.A., Geological Survey Department, Wellington.*
Orchiston, J., M.I.E.E., 8 Tawa Street, Eastbourne.
Orr, Robert, Heke Street, Lower Hutt, Wellington.

Parry, Evan, B.Sc., M.I.E.E., care of Preece Calderwood Rider, 8 Queen Anne's Gate, Westminster, London.
Patterson, Hugh, Engineer, Public Works Department, Wellington.
Penseler, W. H., Hudlart Parker Bldgs., Wellington.
Peren, G. S., Professor of Agriculture, Victoria University College, Wellington.
Phillipps, W. J., F.L.S., Dominion Museum, Wellington.
Phillips, Capt. J., Victoria University College, Kelburn.
Pigott, Miss Ellen, M.A., Victoria University College, Wellington.
Pilcher, E. G., 225 The Terrace, Wellington.
Plank, C. S., Telegraph Engineers' Department, G.P.O., Wellington.
Pomare, Hon. Sir Maui, M.P., Wellington.
Pope, F. S., Assistant Director of Agriculture, Wellington.
Powles, E. R., 34 Wesley Road, Wellington.

Ralph, T., 85 Webb Street, Wellington.
Rands, Henry, Wellington Gas Company (Limited), Miramar.
Reakes, C. J., D.V.Sc., M.R.C.V.S., Agriculture Department, Wellington.
Richardson, C. E., P.O. Box 863, 11 Grey Street, Wellington.
Richardson, H. E., Box 863, Wellington.
Roberts, J. W., 12 Vallance Street, Kilbirnie.
Robertson, Dr. H. Graham, C.B.E., 131 Willis Street, Wellington.
Robertson, Professor P. W., Victoria University College, Wellington.
Robinson, W. D., 274 Taranaki Street, Wellington.
Ross, W. G., P.O. Box 863, Wellington.
Russell, J. W., Banks College, Wellington.

Sangster, Mrs., Ohangai, Hawera.
Saunders, G F., High School, Gisborne.
Seed, Arthur J., Clarke Street, Khandallah.
Seelye, F. T., Dominion Laboratory, Wellington.
Sharp, H., Engineer-in-Chief, Public Works Department, Wellington.
Shrimpton, E. A., Telegraph Department, Wellington.
Sladden, H., Woburn Road, Lower Hutt, Wellington.
Smith, J. R., District Telegraph Engineer, G.P.O., Wellington.
Smith, R. D., Book-seller, opp. "Dominion," Wellington.
Sommerville, Professor D. M. Y., M.A., D.Sc., F.R.S.E., F.N.Z.Inst., Victoria University College, Wellington.
Spidy, E. T., Production Engineer, Railway Department.

Sunley, R. M., View Road, Karori.
Sutherland, W. S., "Kawaroa," Oparau Ferry, via Te Awamutu.
Tennant, J. S., Training College, Kelburn.
Teviotdale, B. B., C/o. A. S. Paterson & Co., Wellington.
Thomson, J. B., Under-Secretary for Lands, Wellington.
Thomson, P., Solicitor, Stratford.
Thomson, W. M., M.A., M.B., Ch.B., Hawera.
Tombs, H. H., Burnell Avenue, Wellington.
Toogood, H. F., Banks Commercial College, Wellington.
Treadwell, C. H., 4 Panama Street, Wellington.
Turner, E. Phillips, F.R.G.S., Forestry Department, Wellington.
Uttley, G., M.A., M.Sc., F.G.S., High School, Masterton.
Waghorn, R. J., 75 Glen Rd., Kelburn.
Wansborough, A. S., Head Office, Railways, Wellington.
Ward, R. H., c/o Box 10, Tauranga.
Waters, R., 71 Fairlie Terrace, Kelburn.
Waterworth, A., Lambton Quay. Wellington.
Webster, H. A., c/o Begg and Co., Manners Street, Wellington.
Westland, C. J., F.R.A.S., Box 63, Apia, Samoa.
Wickens, A. S., 81 Northland Road, Wellington.
Widdop, F. C., District Railway Engineer, Thorndon Office, Wellington.
Wilkinson, A. S. Caretaker, Kapiti.
Wilson, Sir James G., Bulls.
Wood, J., Inspecting Engineer, Public Works Department, Wellington.
Wright, N. L., Dominion Laboratory, Wellington.
Wyles, G. W., Assistant Signal Engineer, Railways, Wellington.
Wynne, H. J., Railway Department, Wellington.

AUCKLAND INSTITUTE.

[*Honorary and life members.]

Abbot, C. E., 83, Queen Street, Auckland.
Abbott, R. A., 36, Shortland Street, Auckland.
Abel, R. S., care of Abel Dykes and Co., Shortland Street, Auckland.
Acheson, Judge F. O. V., Native Land Court, Auckland.
Adams, C. E., LL.B., Hokitika.
*Adams, L., 12 Ewington Avenue, Mt. Eden.
Aickin, Dr. C. G., Symonds Street, Auckland.
*Aimer, K. W., Architect, 423 N.Z. Insurance Buildings, Auckland.
Alexander, J., Selbourne Chambers, Auckland.
Alexander, L. W., Cargen Hotel, Auckland.
Algie, Professor R. M., M.A., University College, Auckland.
Alison, Hon. E. W., M.L.C., Devonport Ferry Co., Auckland.
*Alison, Ernest, Takapuna.
*Alison, E. W., jun., Bank of N.Z. Chambers, Swanson Street, Auckland.
Allan, W. Thurston, Esmond Av., Takapuna.
Allison, James, Boarding House, Pukemiro.
Allum, John, Anzac Avenue, Auckland.
Alpe, R. E.. Box 698, Auckland.
Ambury, S. J., Greenwood's Corner, Onehunga.
*Anderson, E., Northern Club, Auckland.
Anderson, Geo. E., Bellverdere, Mt. St. John.
Anderson, Professor W., M.A., University College, Auckland.
*Andrews, F. N. care of Andrews & Clark, Queen Street, Auckland.
Andrews, J. C., M.Sc., University College, Auckland.
Archdall, Very Rev. H. K., King's College, Otahuhu.
Archey, Gilbert, M.A., F.Z.S., The Museum, Auckland.
Ardern, P. S., M.A., Remuera.
Arey, W. E., Shortland Street, Auckland.
Armitage, F. L., The Hospital, Auckland.
Arnold, C., Sanford's Buildings, Auckland.
Arnoldson, L., Quay Street, Auckland.
Arthur, T. B., Upper Queen Street, Auckland.
Ashton, E. D., Gas Company, Auckland.
*Astley, Frank, E. Astley & Sons, New Lynn.
Atkinson, H. G., 5 Hopetown St., Auckland.

Averill, Most Rev. Dr A. W., Bishopscourt, Parnell.
Bagnall, R. D., Northern Club, Auckland.
Baker, C. C., Lister Buildings, Auckland.
*Bankart, A. S., Strand Arcade Queen St., Auckland.
*Bankart, F. J., Swanson Street, Auckland.
Barr, J., Public Library, Wellesley St., Auckland.
Bartley, C., Savings Bank, Auckland.
*Bartlett, W. H., 255 Stanley Point Road, Stanley Point.
Bartrum, Professor J. A., M.Sc., University College, Auckland.
*Bates, T. L., Alfred Street, Waratah, Newcastle, New South Wales.
Bealing, Fred J., Alexander Avenue, Mt. Albert.
Beattie, Dr. R. M., Mount Albert.
Beecroft, H. C., M.A., Training College, Epsom.
Bell, G. B., Engineer's Office, Harbour Board, Auckland.
Bell, R. W., Lister Buildings, Auckland.
*Bennett, C. F., N.Z. Insurance Building, Auckland.
Binney, E. H., care of Binney & Sons, Customs Street, Auckland.
Bishop, J. J., Dunvegan, Titirangi, Auckland.
Bishop, T. A., B.A., Exhibition Drive, Titirangi.
Biss, Raymond, Victoria Avenue, Remuera.
Blomfield, E. C., Shortland Street, Auckland.
Bloodworth, T., 36 Scarborough Terrace, Parnell.
*Bloomfield, E. R., Northern Club, Auckland.
*Bloomfield, H. R., St. Stephen's Av., Parnell.
*Bloomfield, J. L., St. Stephen's Av., Parnell.
Bodle, Frank H., Birkenhead.
Borrie, Dr. W. Gillies, York Chambers, Auckland.
Borgia, Rev. Bro., Sacred Heart College, Auckland.
Boucher, P. F., Kumeu.
Bowyer, S. B., 14 Warick Street, Morningside.
Boylan, Mrs. A. M., 23 Cheltenham Terrace, Devonport.
Bradley, Samuel, Onehunga.
Brame, J. W., 69 Crummer Road, Grey Lynn.
*Brett, Arthur, "Star Office," Auckland.
Brookes, A. E., Okauia, Matamata.
Brown, A. St. Clair, P.O. Box 557, Auckland.
*Brown, Miss E., Kohi, Ascot Avenue, Remuera.
Brown, E. A., 66 St. Stephen's Avenue, Parnell.
Brown, F. Barnard, 194 Remuera Rd., Auckland.
Brown, Mrs. J., 4 Ascot Av., Remuera.
*Browne, Miss L. M., Bellvue, Norman's Hill, Onehunga.
Brownlee, Mrs., 155 Remuera Road, Remuera.
Bruce, W. W., Williamson's Chambers, Auckland.
*Buchanan, A., Legal Chambers, Wyndham Street, Auckland.
Bucknill, Dr. C. E. R., Mount Maunganui, Tauranga.
Buddle, C., Wyndham Street, Auckland.
Buddle, F. C., Victoria Arcade, Auckland.
*Buddle, H. D., Victoria Avenue, Remuera.
Burbidge, Professor, P.W., M.Sc., University College, Auckland.
*Burns, R., Customs Street, Auckland.
Burt, A., care of A. & T. Burt, Ltd., Customs Street, Auckland.
Bush, W. E., City Engineer, Auckland.
Butler, C. O., Stewart, Johnston and Hough, Auckland.
Butler, J., Kauri Timber Co., Customs Street, Auckland.
Buttle, J., Selwyn Road, Epsom.
Cadman, F. P., care of Gillett Motors, Ltd., 166 Albert Street, Auckland.
Calder, Rev. Jasper, 67 Park Road, Auckland.
Caldwell, D. R., Cambridge.
Cameron, H. T., Premier Buildings, Auckland.
Campbell, A. D., Northern Club, Auckland.
Campbell, Mrs. J. P., 16 Arney Crescent, Remuera.
Carr, Austin, Messrs. Carr, Poutney and Co., Auckland.
Carlaw, J., 9 Herbert Road, Mt. Eden, Auckland.
Carpenter, J. M., Newmarket.
Carse, H., Moata Road, Onehunga.
Carter, A. M., Hallenstein's Buildings, Auckland.
Casey, W., Hamilton Road, Ponsonby.
*Catchpole, J., 45, St. Mary's Road, Ponsonby.
Caughey, A. C., care of Smith & Caughey, Queen Street, Auckland.
Caughey, J. Marsden, care of Smith & Caughey, Queen Street, Auckland.
Chambers, S. G., 23 Shortland Street, Auckland.
Chatfield, Dr. H. A., York Chambers, Auckland.
Cheal, P. E., Cameron Road, Remuera.

Choyce, H. C., Remuera Road, Remuera.
Clark, A., Wellesley Street, Auckland.
Clark, M. A., Wellesley Street, Auckland.
Clark, R. G., care of Robertson Bros. Quay Street, Auckland.
Clay, T. B., Allendale Road, Mount Albert.
*Clayton, D. L., Kauri Timber Co., Customs Street, Auckland.
Clinch, J. A., Ph.D., Training College, Auckland.
Closs, Dr. J. R., York Chambers.
Clouston, Miss. L., St. Cuthbert's College, Auckland.
*Coates, Sir James, Burrow's Avenue, Parnell.
Cochrane, N. D., 20 Belle View Road, Auckland.
Cockroft, H. P., Winstone's Buildings, Auckland.
Coe, James, Lucerne Road, Auckland.
Colbeck, W. B., New Zealand Insurance Buildings, Auckland.
Coleman, J. W., Lower Queen Street, Auckland.
Colwill, J. H., Swanson Street, Auckland.
Comyns, C. C., P.O. Box 1712, Auckland.
*Combes, F. H., Victoria Avenue, Remuera.
Cooper, A. N., Reid, Towle & Cooper, High Street, Auckland.
Copeland, M., 22 Sentinel Road, Herne Bay.
Cory-Wright, S., M.C., B.Sc., 1 Claybrook Road, Parnell.
*Coughlan, W. N., Native School, Omaio, Bay of Plenty.
*Court, A. H., Queen Street, Auckland.
Court, A. J., G. Court & Sons, Karangahape Road, Auckland.
Court, J., Hamilton Road, Auckland.
Court, J. W., Birkenhead, Auckland.
*Cousins, H. G., M.A., Training College, Auckland.
*Craig, E. A., "Manukura," 17, Symonds Street, Auckland.
Craig, J. C., care of J. J. Craig, Ltd., Queen Street, Auckland.
Cranwell, Miss Lucy, " The Delta," Henderson.
Crisp, Mrs. J., 7 Woodley Avenue, Remuera.
Croll, C. H. J., Birkdale Road, Birkdale.
*Crompton, W. J., 3 Mt. Pleasant Rd., Mount Eden.
Crook, John E., 177 Vauxhall Road, Devonport.
Crookes, Miss M. W., Maungawhau Rd., Epsom.
Crosby, John R., Lynwood Road, New Lynn.
Crowther, W. J., Remuera Road, Auckland.
Dale, T. J., Tennyson Street, Birkenhead.
Davis, Eliot R., care of Hancock & Co., Customs Street, Auckland.
Davis, Ernest, care of Hancock & Co., Customs Street, Auckland.
Dawes, Miss, University College, Auckland.
Dawson, Bertram, Victoria, Avenue, Remuera.
Dearsly, H. P., P.O. Box 466, Auckland.
De Clive Lowe, Dr., Lr. Symonds St., Auckland.
De Courcy, Dr. Grace, Market Road, Remuera.
De Guerrier, F. E., Tramway Offices, Auckland.
Delph, L. W., M.A., King's College, Otahuhu.
Dempsey, J., Newmarket.
*Dickson, J. F. W., Barrister, Queen Street, Auckland.
*Dignan, F. J., Northern Club, Auckland.
Dixon, C. E., B.Sc., University College, Auckland.
Donald, J. B., P.O. Box 291, Auckland.
Draffin, M. K., M.C., 423, N.Z. Insurance Buildings, Auckland.
Drier, Dr. E. Newton, Symonds St., Auckland.
Drummond, J., M.A., Grammar School, Auckland.
"D.S.C.," Messrs. Cousins & Cousins, Auckland.
Duder, Albert, 42, Hinemoa Road, Devonport.
Dukes, Dr., Symonds St., Auckland.
Duvall, F. C., Sharlands Ltd., Shortland St.
Eady, A., Arthur Eady Ltd., Queen Street, Auckland.
Eady, L. A., Lewis Eady, Ltd., Auckland.
Earl, F., K.C., Swanson Street, Auckland.
Easdown, Thomas, National Bank of N.Z., Auckland.
Edgerley, Miss K., Girls' Grammar School, Auckland.
Edmiston, H. J., care of Champtaloup & Edmiston, Queen Street, Auckland.
Edwards, Henry, Farmers' Freezing Co.
Egerton, Professor C. W., University College, Auckland.
Elliffe, J. M., Premier Buildings, Auckland.

Ellingham, W. R., Customs Street, Auckland.
Elliot, Sir George, Imperial Buildings, Auckland.
Elliot, W., Imperial Buildings, Auckland.
Elliott, Sidney J., Mountain Road, Mt. Eden.
Ellis, A. F., Argyle Street, Ponsonby.
Ellis, L. V., 9 Seymour Street, Herne Bay.
*Endean, W. P., Endean's Buildings, Auckland.
Entrican, A. J., Customs Street, Auckland.
Entrican, J. C., Customs Street, Auckland.
Ewen, J. F. A., care of Sargood, Son & Ewen, Ltd., Victoria Street West, Auckland.
*Fairclough, Dr. W. A., Imperial Buildings, Auckland.
Falla, R. A., M.A., 41 Calliope Road, Devonport.
Farrell, R., Anglesea Street, Auckland.
Fenwick, Dr. G., A.M.P. Buildings, Auckland.
Ferguson, A. M., C/o. John Burns & Co., Customs St., Auckland.
Firth, R. W., M|A., Ph.D., Wymondsley Road, Otahuhu.
Fisher, F. S., Kauri Road, Birkdale.
Fisher, J. P., Pukeora Av., Remuera.
Fisher, V. F., Kauri Road, Birkdale.
*Fleming, G. H., Remuera Road, Remuera.
Fleming, J., 142 Grafton Road, Auckland.
Flinn, Mrs. Eleanor, 15, Queen's Parade, Devonport.
Florance, R. S., Barrister, Russell, Bay of Islands.
Ford, C. Reginald, F.N.Z.I.A., N.Z. Insurance Buildings, Auckland.
Fotheringham, Alex., 7a, Williamson's Chambers, Auckland.
*Fowlds, Hon. G., C.B.E., Queen St., Auckland.
Fowlds, G., jun., Queen Street, Auckland.
Fraser, W. M., C.E., Whangarei.
Frater, James H., Frater Bros., Queen Street, Auckland.
Frater, J. W., Stock Exchange, Auckland.
Friedlander, Hugo, P.O. Box 10, Newmarket.

Gamble, F. W., Grammar School, Mount Albert.
*Gardner, C. F., New Lynn.
Gardner, J. L., New Lynn
Garland, Hon. C. J., M.L.C., Beaconsfield Street, Grey Lynn.
Garrett, Wm., 40, Ladies Mile, Remuera.
Gauvain, W. P., 60, Shortland St., Auckland.
Geddes, A., Brown, Barrett & Co., Customs Street, Auckland.
Geddes, R., 23, Maurice Avenue, Remuera.
Gibbons, Ernest H., Box 578, Auckland.
Gibson, Noel, M.A., Dilworth Institute, Remuera.
Gilfillan, H., St. Stephen's Avenue, Parnell.
Gilmour, Dr., The Hospital, Auckland.
Gill, H. N., Kauri Timber Co., Normanby Road, Auckland.
Gillett, J., Holland & Gillett, Albert Street, Auckland.
Gillies, A. W., Manurewa, Auckland.
Glaister, D. M., Ellison's Chambers, Auckland.
*Goldie, A., Wallace Street, Ponsonby.
Goldie, H., Imperial Buildings, Auckland.
Goldstein, Dr. H. M., 41, Shortland Street, Auckland.
Gordon, Dr. F. W., Hillsborough.
Graham, A. G., care of Briscoe & Co., Customs Street, Auckland.
Graham, David H., Narrow Neck, Auckland.
Graham, G., Endean's Buildings, Auckland.
Graham, J. B., Endean's Buildings, Auckland.
Grant, Miss J., M.A., Devonport.
*Gray, A., Winstone's Buildings, Queen Street, Auckland.
Gray, Alan A., care of G. W. Wilton & Co., Shortland Street, Auckland.
Gray, S., Town Clerk, Mt. Eden.
Gray, W. A., M.I.C.E., Smith's Bldgs., Auckland.
Greig, Dr. W. C., P.O. Box 11, Feilding.
Gribbin, G., Imperial Buildings, Auckland.
Grierson, H. C., Architect, 423 N.Z. Insurance Buildings, Auckland.
Griffin, L. T., F.Z.S., Assistant Curator, Museum, Auckland.
Gross, R. O., Manukau Road, Epsom.
Gulliver, T. V., Smith's Buildings, Auckland.
Gummer, W. H., N.Z. Insurance Buildings, Auckland.
*Gunson, Dr. E. B., Princes Street, Auckland.
Gunson, Sir James, C.M.G., C.B.E., "Ngaruru," St. Andrew's Road, Auckland.

Haddow, J. G., Wyndham Street, Auckland.
Hammond, Arthur B., Kauri Timber Co., Auckland.
Harbutt, S. J., Selwyn Road, Epsom.

Hardley, J. W., Customs Street, Auckland.
Harkness, D. E., D.S.C., B.E., University College, Auckland.
Harris, Lewis, Huntly.
Harvey, A., Lower Albert Street, Auckland.
Harvey, Mrs., 7, Beckham Place, Auckland.
Harwood, W. G., Grammar School, Auckland.
Hay, D. A., Montpellier Nursery, Remuera.
Hay, Douglas, Stock Exchange, Auckland.
Hay, Miss, Grafton Road, Auckland.
*Hellaby, F. A., Hellaby's, Ltd., Auckland.
Henning, G., 36 Remuera Road, Remuera.
Henry, J. B., Bank of New Zealand, Auckland.
Hesketh, H. R., care of Hesketh and Richmond, Wyndham Street, Auckland.
Hesketh, S., care of Hesketh and Richmond, Wyndham Street, Auckland.
Hill, J. C., care of Hill and Plummer, Queen Street, Auckland.
Hills, F. M., Arney Road, Remuera.
Hitchcock, Mrs. G. E., Remington Bldgs., Fort St., Auckland.
Hodgkins, W. J. P., Bank of New South Wales, Auckland.
Holderness, D., Harbour Board Offices, Auckland.
Holdsworth, W. J., Albert Street, Auckland.
Holmden, Dr., Jervois Road, Ponsonby.
Holmes, W. R., P.O. Box 333, Auckland.
Horton, E., "Herald" Office, Auckland.
Horton, H., "Herald" Office, Auckland.
Horton, Dr. W. H., 78 Symonds Street, Auckland.
*Houghton, C. V., 8 Gladstone Road, Parnell.
Hovell, S. W., Kenny Street, Waihi.
Hudson, G., Mount Eden Road, Auckland.
Hudson, J. H., G.P.O., Auckland.
Hume, Alan, Solicitor, Shortland St., Auckland.
Hunter, Ashley, C.E., P.O. Box 1649, Auckland.
Hunter, James, Hunter & Sons, Elliot Street, Auckland.
Hutchinson, A. J., N.Z. Insurance Buildings, Auckland.
Hutchinson, Major G. R., O.B.E., Hutchinson's Ltd., Auckland.
Hutchison, G. W., Premier Buildings, Auckland.
Hyatt, H. R., 8, Lillington Road, Remuera.
*Inder, E. W., Barrister, P.O. Box 1089, Auckland.
Inglis, Dr. R. T., C.B.E., Alfred Street, Auckland.
Jackson, J. H., 9, Commerce Street, Auckland.
Jackson, Thornton, Shortland Street, Auckland.
Jenkins, C. H., 108, Albert Street, Auckland.
Johnston, J. B., care of Stewart and Johnston, Wyndham Street, Auckland.
Johnstone, A. H., Solicitor, Selbourne Chambers, Auckland.
Johnstone, Hallyburton, Point Chevalier.
Joll, L., Mount Eden.
Jones, D. A., East Tamaki.
*Jones, Hugh K., 21, Wapiti Avenue, Epsom.
Julian, T. G., P.O. Box 361, Auckland.
*Kenderdine, J., Sale Street, Auckland.
Kent, G. S., 14, Fairfax Road, Epsom.
Kingston, J. J., South British Insurance Co., Auckland.
Kirk, Robt., Grand Vue, Rotorua.
Kissling, H. P., St. Stephen's Avenue, Parnell.
Knight, Professor C. R., University, Auckland.
Knight, G., Asquith Avenue, Mt. Albert.
Kohn, E. S., Queen St., Auckland.
Laidlaw, R. A., Hobson Street, Auckland.
Lamb, J. A., Arney Road, Remuera.
Lamb, S. E., B.Sc., University College, Auckland.
Lancaster, T. L., M.Sc., University College, Auckland.
Lang, Sir F. W., Queenstown Road, Onehunga.
Langridge, Cecil, Avondale.
*Larner, V. J., Swanson St., Auckland.
La Roche, Sydney, B.Sc., Wapiti Avenue, Auckland.
*La Roche, W., Wapiti Avenue, Remuera.
La Roche, W. E., B.Sc., Wapiti Avenue, Remuera.
Laurie, B. A., care of W. S. Laurie & Co., Customs Street, Auckland.
Leece, Edw., Birkenhead.
Leech, E. Duff, Wellesley House, Auckland.
Le Roy, E., Queen Street, Auckland.
Lewis, Miss Nora, Panmure.
Leyland, S. H., care of Leyland and O'Brien, Customs Street W., Auckland.
Leyland, W. B., care of Leyland and O'Brien, Customs Street W., Auckland.

*Leys, W. Cecil, "Star" Office, Auckland.
Lloyd, Miss Olive, "The Grove," Onehunga.
Logan, R., P.O. Box 536, Auckland.
Low, T. A., Hennings, Ltd., Auckland.
Lowe, James, C.E., Gas Co., Auckland.
*Lunn, A. G., care of Collins Bros., Wyndham Street, Auckland.
Lusk, H. B., M.A., King's College, Otahuhu.
Macdonald, Rev. Angus, O.B.E., The Manse, Richmond.
Macdonald, Hugh R., 47, St. Stephen's Avenue, Parnell.
Macfarlane, J. B., 59, Fort St., Auckland.
*Macindoe, Charles G., Little Queen Street, Auckland.
Mackay, G. J., Queen Street, Auckland.
Mackay, J. G. H., Ellison Chambers, Auckland.
Macky, Dr. Frank, Lister Buildings, Auckland.
Macky, T. H., care of Macky, Logan & Co., Elliott Street, Auckland.
Mackenzie, H. R., Acacia Building, Auckland.
Mackenzie, Kenneth, F.R.C.S., Princes Street, Auckland.
*Macmillan, C. C., 36 Mt. Hobson Rd., Auckland.
MacMurray, Ven. Archdeacon, Mt. Hobson Road, Auckland.
Mahon, H. G. D., B.A., Grammar School, Auckland.
Mair, S. A. R., Hunterville, Wellington.
*Major, C. T., C.B.E., D.S.O., Auckland.
Makgill, John E., Wapiti Avenue, Epsom.
Makgill, Dr. R. H., Health Department, Wellington.
*Mander, Hon. F., Ranfurly Road, Epsom.
Mander, L. A., M.A., University College, Auckland.
*Mappin, F. Crossley, Mountain Road, Epsom.
Marks, L., Chancery Street, Auckland.
Marshall, J., Te Ataahua, Remuera Road, Auckland.
Martin, R. M., Northern Club.
Massey, F. G., Swanson Street, Auckland.
Mason, Mrs. F., West Town, New Plymouth.
Matheson, H. C., 101, Albert Street, Auckland.
Matthews, H. B., Clonbern Road, Remuera.
McArthur, M. G., Ellison's Chambers, Auckland.
McCallum, W. F., Endean's Bldgs., Auckland.
McClymont, Miss J., 40, City Chambers, Auckland.
McCullough, J. A., "Star" Office, Auckland.
McDonald, Rev. W., Gardner Road, Epsom.
McGregor, W. R., University College, Auckland.
McIntosh, Mrs. J. B., P.O. Box 1208, Auckland.
McKenzie, Capt G., Devonport.
*McMillan, G. G., McMillan & Co., Auckland.
McMillan, Gibson A., C/o. R. C. Carr & Sons, Swanson St., Auckland.
McVeagh, James, 410, N.Z. Insurance Buildings, Auckland.
McVeagh, R., O'Connell Street, Auckland.
Mellor, Thos. W., Tophouse, Nelson.
Merritt, H. T., Anzac Avenue, Auckland.
Metcalfe, G. H., Barrister, P.O. Box 1089, Auckland.
Miller, E. V., 71, Upland Road, Remuera.
*Miller, M. H., 410 Chancery Chambers, Auckland.
Miller, Thomas, "Craigmore," Argyle Street, Auckland.
Millet, L., Te Kopuru, N. Wairoa.
Milne, J., care of John Chambers & Son, Fort Street, Auckland.
Milne, Stewart, care of Milne & Choyce, Queen Street, Auckland.
Milsom, Dr. E. H. B., 18, Waterloo Quadrant, Auckland.
Mincher, W., 3, Brentwood Avenue, Mount Eden.
Mitchell, J. T. F., Wright Stephenson and Co., Auckland.
Mitchelson, E. P., P.O. Box 873, Auckland.
Mitchelson, Hon. Sir E., K.C.M.G., M.L.C., Waitaramoa, Remuera.
Moodie, F. L., Victoria Arcade, Auckland.
Moore-Jones, Mrs. S. A., The Ladies' College, Remuera.
*Montgomery, T. E., Clarence Street, Devonport.
Morrison, Miss A. C., Girls' Grammar School, Epsom.
Morpeth, H., Hallenstein's Buildings, Auckland.
*Morton, E., P.O. Box 11, Auckland.
Morton, H. B., Taumata, Wapiti Avenue, Epsom.
Moses, H. C., No Deposit Piano Co., Upper Queen St., Auckland.
Moses, L. V., Victoria Arcade, Auckland.
Mulgan, A. E., "Star" Office, Auckland.
Munro, G. H., M.Sc., 96, Grafton Road, Auckland.

Myers, B., "Cargen," Auckland.
Nalder, E. E., Commercial Bank Buildings, Auckland.
Nathan, C. I., Customs Street, Auckland.
Nathan, D. L., Shortland St., Auckland.
*Nathan, N. A., Shortland St., Auckland.
Neil, Dr. Hardie, D.S.O., Symonds St., Auckland.
Neumegen, W. M., P.O. Box 277, Auckland.
Niccol, G., Customs Street W., Auckland.
Nicholson, O., Imperial Buildings, Auckland.
Noakes, B., C/o. John Burns & Co., Customs St., Auckland.
Northcroft, Lieut.-Col. E. H., D.S.O., Swanson Street, Auckland.
*Norton, H., Pentland, Imperial Buildings, Auckland.
Noonan, Dr., Milford.
*O'Brien, J. J., Endean's Buildings, Auckland.
Oliver, James, S. A. Smith and Co., Auckland
*Oliver, W. R. B., F.L.S., F.N.Z.Inst., Dominion Museum, Wellington.
Oram, N. F., 41 Edenvale Rd., Mount Eden.
*Osborne, Mrs. 27 Great South Road, Auckland.
Parr, Hon. Sir James, K.C.M.G., High Commissioner, London.
Parr, P. R., M.Sc., Atarange Road, Greenlane, Auckland.
Parkes, Dr. W. H., C.M.G., C.B.E., Symonds Street, Auckland.
Partridge, H. E., Albert Street, Auckland.
*Partridge, H. H., Albert Street, Auckland.
*Patterson, D. B., 23 Shortland Street, Auckland.
Peacock, J. A., Queen Street, Auckland.
*Perkins, A. W., C/o. Dalgety & Co., Auckland.
Perks, T. E., 8 Coombes Road, Remuera.
Pezaro, Dr. M. G., 3, Remuera Road, Auckland.
*Philcox, T., 11 Fairview Road, Mt. Eden.
Pond, J. A., F.C.S., 214 Remuera Road, Auckland.
Potter, E. H., P.O. Box 230, Auckland.
Potter, R. H. A., Union Oil, Soap and Candle Co., Auckland.
Powell, A. W. B., Shortland Street, Auckland.
Powell, F. E., C.E., Ferry Buildings, Auckland.
Price, E. A., Cambria Park, Papatoetoe.
Prins, Dr. H. M., Gladstone Rd., Mt. Albert, Auckland.
Prosser, T. C. W., 12, Westbourne Rd., Remuera.
Pryor, S. H., Hillside, New Lynn.
Pulling, Miss, Selwyn Court, Parnell.
Purchas, Dr. A. C., Symonds St., Auckland.
*Pycroft, A. T., Edward Street, St. Heliers, Auckland.
Quartley, A. G., M.B.E., Barrister, Vulcan Lane, Auckland.
Ralph, W. J., Princes Street, Auckland.
Rangihiroa, Dr., D.S.O., F.N.Z. Inst., Bishop Museum, Honolulu.
Ratcliff, W., P.O. Box 259, Hamilton.
Rawnsley, S., Federal Street, Auckland.
Rayner, Dr. F. J., Queen Street, Auckland.
Reed, Hon. Mr. Justice, Supreme Court, Wellington.
Reed, Hon. Vernon, Paihia.
Rendell, J. R., Karangahape Road, Auckland.
Rennie, Mrs., C/o. "Sun" Office, Auckland.
Rennie, J. M., "Sun" Office, Auckland.
Renshaw, F., care of Sharland & Co., Lorne Street, Auckland.
Reyburn, J. H., Ellison's Chambers, Auckland.
Rhodes, Miss B., Diocesan School, Auckland.
Rhodes, C., Ronaki, Remuera.
Richardson, J. D., Savings Bank, Newton.
Richmond, H. P., Arney Road, Remuera.
Riddet, Professor Wm., University College, Auckland.
*Rishworth, J. N., Lister Buildings, Auckland.
Robb, J., Victoria Avenue, Mount Eden.
Roberton, A. B., Fort St., Auckland.
Roberton, Dr. E., Market Road, Remuera.
Robertson, Carrick, F.R.C.S., Alfred Street, Auckland.
Robertson, Jas., Market Road, Remuera.
Rogerson, H. M., Imperial Buildings, Auckland.
Rollett, F. C., "Herald" Office, Auckland.
Ropiha, T. T., Survey Office, Auckland.
Rowden, Fred J., Howick.
Rowe, W. Page, Seaview Rd., Remuera.
Rukutai, J., Wright's Bldgs., Auckland.
Russell, E. R. N., Princess St., Auckland.
Russell, F. Montague, Remuera Road, Auckland.

Russell, John E., Russell, Campbell & McVeagh, Auckland.
Ryan, James, Riverview, Otahuhu.
Salt, G. MacBride, M.Sc., University College, Auckland.
Sanford, Gilbert, Sandford Ltd., Auckland.
*Schnauer, Charles, Shortland Street, Auckland.
Scott, D. D., care of Kempthorne, Prosser & Co., Albert Street, Auckland.
Scott, Rev. D. D., The Manse, Onehunga.
Segar, Professor H. W., M.A., F.N.Z. Inst., University College, Auckland.
*Seth Smith, H. G., 88 Victoria Avenue, Remuera.
Shakespear, Mrs. R. H., Whangaparaoa.
Shannon, J. W., 16 Dromorne Road, Remuera.
*Shaw, C. J., Fairview Road, Mount Eden, Auckland.
Shaw, H., care of Public Library, Auckland.
Shepherd, E. C., Lake Waikare, Te Kauwhata.
Short, W. F., M.Sc., University College, Auckland.
Shrewsbury, H., St. John's Avenue, Epsom.
*Shroff, H. R., 44 Remuera Rd., Auckland.
Simmonds, Rev. J. H., Princess Street, Takanini.
Simmonds, L., 180, Karangahape Road, Auckland.
Simson, T., Mount St. John Avenue, Epsom.
Sinclair, G., 321 Queen Street, Auckland.
Skeet, H. M., 14 Dilworth Avenue, Remuera.
Sladden, Bernard, Box 17, Tauranga.
Smith, F. W., 1 Eden Crescent, Auckland.
Smith, S. A., P.O. Box 843, Auckland.
Smith, Mrs. W. H., Princes St., Auckland.
Smith, W. Todd, P.O. Box 1062, Auckland.
Somerville, Dr. J., Alfred St., Auckland.
Somerville, J. M., Birkenhead, Auckland.
Spencer, Albert, Kingston Street, Auckland.
Spence, A. L., Messrs. Stanton, Johnstone and Spence, Auckland.
*Sperrin-Johnson, Professor J. C., Litt. D., University College, Auckland.
Stanton, J., Selbourne Chambers, Auckland.
Stevenson, Arthur G., Gladstone Road, Mt. Albert.
Stewart, D. F., care of R. S. Lamb & Co., 32 Jamieson Street, Sydney.
Stewart, John A., Kainga-town, Ranfurly Road, Epsom.
Stewart, R. Leslie, care of Brown & Stewart, Swanson Street, Auckland.
*Stewart, Hon. W., M.L.C., Kawakawa.
Stocker, Mrs. G. W., 33 Burwood Ave., Remuera.
Straker, Miss Marjorie, Hall Ave., Otahuhu.
*Sullivan, J. J., Barrister, P.O. Box 1175.
Suter, A., P.O. Box 113, Auckland.
Swan, H. C., Henderson.
Talbot, Dr. A. G., A.M.P. Buildings, Auckland.
Taylor, C. N., 2 Oliver Street, Remuera.
Taylor, Norman H., Maungawhau School, Mt. Eden.
Thomas, Professor A. P. W., F.L.S., F.N.Z. Inst., Mountain Road, Epsom.
Thorne-George, Sidney, Govt. Life Insce. Buildings, Auckland.
Thornes, J., 231 Parnell Road, Parnell.
Tilly, C. S. R., 85 Victoria Avenue, Remuera.
*Tinne, H., Union Club, Carlton House Terrace, London, S.W.1.
Tomlinson, L. H., Electric Construction Co. of N.Z., 52 Fort Street, City.
Towle, R. P., Reed, Towle and Cooper, High Street, Auckland.
*Trenwith, Martin, Pioneer Boot Factory, Auckland.
Trounson, J., Northcote.
Tunks, C. J., Shortland St., Auckland.
Turner, E. C., C/o. Turner & Growers Ltd., Market Square, Auckland.
Uhlmann, Miss J. L., Girls' Grammar School, Auckland.
Upton, J. H., St. Stephen's Avenue, Parnell.
*Upton, P., South British Insurance Co., Auckland.
Upton, P. T., P.O. Box 878, Auckland.
Utting, H., Town Clerk, Mount Albert.
*Vaile, Miss A. B., 9 Arney Road, Remuera.
*Vaile, E. E., Broadlands, Waiotapu.
*Vaile, H. E., Queen Street, Auckland.
Veale, P. O., M.Sc., 1 Beresford Street, Auckland.
Wade, Dr. Wallace, Elliott Street, New Plymouth.
Wake, F. W., 73 Remuera Road, Remuera, Auckland.
Wallace, Dr. B., 21, Orakei Road, Remuera.
Wallace, T. F., 1 Claude Road, One Tree Hill.
Wallace, W., Chairman Hospital Board, Auckland.

*Walker, A. Howey, Queen Street, Auckland.
Walsh, Edmund, Water Lane, New Plymouth.
Warnock, A. E., Union Buildings, Auckland.
Warnock, J. A., 2 King Street, Grey Lynn.
Watt, W. M., Dredging Office, Harbour Board, Auckland.
Waymouth, G. W., Rarere Road, Takapuna.
Wells, J. F., School House, Matamata.
Wells, T. U., Westbourne Road, Remuera.
Wheeler, Thomas, Stanmore Road, Grey Lynn.
Whitcombe, Hugh, P.O. Box 63, Auckland.
White, George M., Skeates and White, Anzac Avenue, Auckland.
White, P. C., care of S. White & Sons, Customs Street West, Auckland.
White, R. W., Wellington Street, Auckland.
Whitley, W. S., Albert Street, Auckland.
Whitney, C. A., Colonial Ammunition Co., Auckland.
Williams, N. T., 74 Remuera Road, Remuera, Auckland.
Williamson, C. R., Fort St., Auckland.
*Williamson, J. D., Northern Club, Auckland.
*Williamson, Julius W., 57, Clifton Road, Takapuna.
Wilson, Andrew, Hillcrest Street, Hamilton East.
Wilson, C. A., P.O. Box 1081, Auckland.
Wilson, F. W., "Herald" Buildings, Auckland.
Wilson, G. H., National Bank Buildings, Fort Street, Auckland.
Wilson, John, 303 N.Z. Insurance Buildings, Auckland.
Wilson, J. A., C/o. A. Eady Limited, Queen Street, Auckland.
Wilson, J. M., Portland Rd., Remuera.
Wilson, Liston, Upland Rd., Remuera.
*Wilson, Martyn, Roselle, Lower Remuera.
*Wilson, Mrs. R. M., Russell Road, Remuera.
Wilson, Mrs. Gilbert, Long Drive, St. Heliers, Auckland.
Wilson, W. R., "Herald" Office, Auckland.
Wily, H., Mauku.
Winklemann, H., Victoria Arcade, Auckland.
*Winstone, F. M., Claude Road, Epsom.
Winstone, G., Junior, Queen Street, Auckland.
*Winstone, G., Senior, Queen Street, Auckland.
Winstone, W. P., Winstone's Buildings, Auckland.
Wiseman, F., Queen Street, Auckland.
Wiseman, J. W., Albert Street, Auckland.
*Wood, Right Rev. C. J., D.D., England.
Woodhead, Miss L., 40, City Chambers, Auckland.
Woollams, W. H., Queen Street, Auckland.
Worley, Professor F. P., D.Sc., University College, Auckland.
Wright, Hugh C., Strand Arcade, Auckland.
Wright, R., C/o. A. B. Wright & Son, Commerce Street, Auckland.
Wright, R., Seabrook Avenue, New Lynn.
Wright, R., junior, Seabrook Avenue, New Lynn.
*Wylie, D. S., P.O. Box 672, Auckland.
Yates, Miss Dorothy, St. Cuthbert's College, Auckland.
Yates, E., Albert Street, Auckland.
Young, J. L., "Meramie," Warren, N.S.W.

PHILOSOPHICAL INSTITUTE OF CANTERBURY.

(" Life Members)

Acland, Dr. H. T. D., 51 Brown's Road, Christchurch.
Acland, H. D., C/o. Wilding & Acland, Hereford Street, Christchurch.
Adams, Hon. Mr. Justice, 29 Wairarapa Terrace, Fendalton.
Alexander, R. E., Canterbury Agricultural College, Lincoln.
Allan, H. H., M.A., D.Sc., F.L.S., Feilding.
Anderson, Mrs. Murchiston, "Sungarth," Kowai Bush.
Askew, H. O., M.A., c/o Cawthron Institute, Nelson.
Baird, H. F., B.Sc., c/o Magnetic Observatory, Christchurch.
Baker, R. D., c/o City Engineer, Wellington.
Bamford, P. G., B.E., Canterbury College, Christchurch.

Barkas, F., Hewling St., Timaru.
Barker, C. S., Canterbury College, Christchurch.
Barnett, W. J. F., 35 Hardwicke Street, Sumner.
Bates, D., 22 Webb Street, Christchurch.
*Beaven, A. W., c/o Andrews and Beaven, Moorhouse Avenue, Christchurch.
Belton, F. J. W., c/o Gas Coy., Ltd., Christchurch.
Bennett, E. W., M.Sc., University of Western Australia, Perth.
Berry, R. E., 165 Manchester Street, Christchurch.
Biltcliff, G. S. A., Canterbury College, Christchurch.
Bingham, S. C., 7 Cashel Street, Christchurch.
Booth, G. T., 242 Papanui Road, Christchurch.
Borrie, Dr. F. J., 236 Hereford Street, Christchurch.
Borrie, Miss, 236 Hereford Street, Christchurch.
Bowker, Geo., 177 Stafford Street, Timaru.
Boys, Sir Francis, c/o N.Z. Refrigerating Co., Ltd., Hereford Street, Christchurch.
*Bradley, Orton, Charteris Bay.
Brittin, Guy, F.E.S., Riwaka, Motueka, Nelson.
Broadhead, H. D., M.A., Litt.D., Canterbury College, Christchurch.
Brock, W., M.A., Merivale Lane, Christchurch.
*Brown, Professor Macmillan, M.A., LL.D., Holmbank, Cashmere.
Burnett, T. D., Cave, S. Canterbury.
Burrows, W. M., Training College, Christchurch.
Calvert, G. G., Canterbury College, Christchurch.
Campbell, Professor R. A., Canterbury College, Christchurch.
Campbell, J. W., Seaview Road, New Brighton.
Candy, F. R., c/o. Tramway Board Office, Christchurch.
Carlyle, Thomas, c/o "Sun" Office, Christchurch.
Cassidy, Mrs. A., Cashmere.
*Chilton, Professor C., D.Sc., M.A., LL.D., F.N.Z.Inst., F.L.S., Canterbury College, Christchurch.
Christensen, C. E., Box 38, Te Aroha.
Clark, W. H., 100 Bealey Avenue, Christchurch.
Coates, C. C., 134 Hereford Street, Christchurch.
Colee, W. C., M.A., Normal School, Christchurch.
Coles, W. R., 358 Gloucester Street, Christchurch.
Cooper, S. A., Canterbury College, Christchurch.
Cornes, J. J. S., B.A., B.Sc., Training College, Christchurch.
Cowley, S. R., 156 Antigua Street, Christchurch.
Cox, P. T., c/o. Anglo-Persian Oil Coy., Britannic House, Finsbury Circus, London, E.C.2.
Deans, James, Homebush.
Deans, Jno., Kirkstyle, Coalgate.
Deans, Wm., Sandown, Waddington.
Denham, Professor H. G., M.A., D.Sc., Ph.D., Canterbury College, Christchurch.
Dobson, A. Dudley, M.Inst.C.E., 76 Merivale Lane, Christchurch.
Dorrien Smith, Major A., D.S.O., Tresco Abbey, Scilly, England.
Dougall, J. J., 105 Clyde Road, Christchurch.
Drummond, Jas., F.L.S., F.Z.S., "Lyttelton Times," Christchurch.
Farr, Professor C. Coleridge, D.Sc., F.P.S.L., F.N.Z.Inst., Canterbury College, Christchurch.
Fitzgerald, Miss, M. S., M.Sc., Waitaki G.H.S., Oamaru.
Flesher, J. A., 169 Hereford Street, Christchurch.
Florance, Miss E., 117 Caledonian Road, Christchurch.
Flower, A. E., M.A., M.Sc., Christ's College, Christchurch.
Foweraker, C. E., M.A., F.L.S., Canterbury College, Christchurch.
Francis, J. W. H., c/o Rhodes, Ross & Godby, Hereford Street, Christchurch.
Galbraith, A. R., City Engineer, Christchurch.
Gale, F. H. D., "Sun" Office, Christchurch.
Gilling, C. D., School, Amberley.
Gilling, W. O. R., M.A., B.Sc., c/o Gas Co., Moorehouse Avenue, Christchurch.
Glover, P. W., Boys' High School, New Plymouth.
Godby, Mrs. M. D., 5 Jackson's Road, Fendalton, Christchurch.
Godby, M. H., M.A., B.Sc., 176 Hereford Street, Christchurch.
Gourlay, H., Boys' High School, Christchurch.
Gower, S. W., Tinwald School, Mid Canterbury.
Graham, Chas. H. E., 26 Gordon Avenue, Christchurch.
Gray, J., 239 Salisbury St., Christchurch.
Grigg, F. J. T., M.Sc., A.I.C., Government Analyst, Government Buildings, Christchurch.
Guthrie, Dr. Jno., Armagh Street, Christchurch.

Hall, G., Hororata.
Hamilton, W. M., 54 Dyer's Pass Road, Cashmere.
Haynes, E. J., F.Z.S., Canterbury Museum, Christchurch.
Herriott, Miss E. M., M.A., Canterbury College, Christchurch.
Hewitt, S. J., 234 Selwyn Street, Christchurch.
Hight, Professor J., M.A., Litt.D., Canterbury College, Christchurch.
*Hilgendorf, F. W., M.A., D.Sc., F.N.Z.Inst., Canterbury Agricultural College, Lincoln.
Hitchcock, E., 159 Rolleston Street, Linwood, Christchurch.
Hogg, E. G., M.A., F.R.A.S., Hackthorne Road, Cashmere, Christchurch.
Holford, Geo., B.Ag., 74 Knowles St., Christchurch.
Holmes, A. G., B.Ag., Canterbury Agricultural College, Lincoln.
Howard, E. J., M.P., 71 Page's Road, Christchurch.
Humphreys, G., Fendalton Road, Fendalton, Christchurch.
Hutchinson, F. E., B.Sc.F., Canterbury College, Christchurch.
Hutton, D. E., A.I.N.Z.A., 26 Naseby Street, Christchurch.
Ironside, Miss A. F., M.A., Training College, Christchurch.
Irving, Dr. W., 56 Armagh Street, Christchurch.
Jameson, J. O., 152 Hereford Street, Christchurch.
Jamieson, W. G., Deans Avenue, Lower Riccarton, Christchurch.
Jeans, Alexander, 24 Peacock Street, Christchurch.
Jobberns, G., M.A., B.Sc., Training College, Christchurch.
Jones, P. H., Waiuta, West Coast.
*Kidson, E., M.A., D.Sc., Central Weather Bureau, Melbourne.
Kidson, J. O., Canterbury College, Christchurch.
Kitson, H., 37 Waiwetu St., Fendalton.
Lancaster, G. J., M.A., M.Sc., Boys' High School, Christchurch.
Laing, H. W., 146 St. Martins Road, Opawa.
Laing, R. M., M.A., B.Sc., F.N.Z.Inst., Hackthorne Road, Cashmere.
Lindsay, Stuart, 18 Sydney Street, Spreydon, Christchurch.
Louisson, Dr. M. G., Royal Exchange Buildings, Cathedral Square, Christchurch.
Lythgoe, J., c/o A. S. Paterson and Co., Christchurch.
Lush, A., B.E., c/o N.Z. Refrigerating Co., Christchurch.
Macbeth, N. L., 18 Hereford St., Christchurch.
Macintyre, A. C., B.D.S., Dominion Buildings, Cathedral Square, Christchurch.
Margolish, H., 54 Hackthorne Road, Cashmere.
Mazey, G. A., 57 Fitzgerald Avenue, Christchurch.
McGillivray, Robert, F.L.S., Agriculture Department, Christchurch.
McKay, Dr. W., 45 Guinness Street, Greymouth.
Macleod, D. B., M.A., D.Sc., Canterbury College, Christchurch.
Mears, F. D., F.C.S., 486 Lincoln Road, Christchurch.
Mill, Dr. Thomas, 29 Knowles Street, Christchurch.
Milligan, Dr. R. R. D., Pathological Dept., Hospital, Christchurch.
Morrison, W. G., Conservator of Forests, Christchurch.
Murray, Miss F. B., M.A., Canterbury College, Christchurch.
Nairn, R., Lincoln Road, Christchurch.
Newburgh, W. S., 95 Gloucester Street, Christchurch.
Oliver, F. S., c/o Papprill, Salter and Gresson, Box 376, Christchurch.
Olliver, Miss F. M., M.A., M.Sc., High School, Waimate.
Ollivier, C. M., St. Martins, Christchurch.
Orbell, Mrs. E. A., Park Lane, Timaru.
Owen, H., c/o Cook & Ross, Christchurch.
Owen, R. B., 751 Colombo Street, Christchurch.
Packer, J., M.Sc., Canterbury College, Christchurch.
Page, R. O., M.Sc., 59 May's Road, Papanui, Christchurch.
Page, S., B.Sc., 59 May's Road, Papanui, Christchurch.
Pairman, Dr. J. C., 21 Latimer Square, Christchurch.
Pairman, Dr. T. W., "Moat Knowe," Governor's Bay.
Parham, B. V., 140 Hills Rd., Shirley, Christchurch.
Payne, A. H., 30 Bishop St., Christchurch.
Pearson, Dr. A. B., Hospital, Christchurch.
Penlington, G., F.N.Z.I.A., Architect's Office, Canterbury Education Board, Christchurch.
Powell, Professor P. H., M.Sc., Canterbury College, Christchurch.
Prudhoe, J. C., 12 Kidson Terrace, Cashmere, Christchurch.
Raymond, S. G., K.C., c/o Raymond, Stringer and Co., Christchurch.
Ridley, G. S., Kingsdown, R. D., Timaru.

Rhodes, J. H., c/o Rhodes, Ross and Godby, 176 Hereford St., Christchurch.
Rhodes, Hon. Sir R. Heaton, Tai Tapu, Canterbury.
Robinson, R. G., Darfield.
Robinson, W. F., F.R.G.S., Canterbury College, Christchurch.
Robinson, W. R., B.A., The School, Kaiapoi.
Rowe, H. V., M.A., Boys' High School, Christchurch.
Rowntree, W. W., 341 Bealey Avenue, Christchurch.
Sawtell, Mrs. C., 20 Cashel Street, Christchurch.
Scott, Mrs. A., 102, Hackthorne Road, Cashmere.
Scott, M. J., Canterbury Agricultural College, Lincoln.
Seager, S. Hurst, F.R.I.B.A., 36 Hackthorne Road, Cashmere.
Sheffield, Mrs. W. H., 263 Cambridge Terrace, Christchurch.
Shelley, Professor J., M.A., Canterbury College, Christchurch.
Shrubshall, A. H., Bowenvale Ave., Cashmere, Christchurch.
*Simpson, Dr. W., cr. Papanui Road and Heaton St., Christchurch.
Sims, A., M.A., c/o Sims, Cooper & Co., Hereford Street, Christchurch.
Skey, H. F., B.Sc., Magnetic Observatory, Christchurch.
Skinner, W. H., 3 York Terrace, New Plymouth.
Smith, Hon. G. J., River Road, Opawa, Christchurch.
Smith, W. W., Niger House, New Plymouth.
Speight, Professor R., M.A., M.Sc., F.G.S., F.N.Z.Inst., Canterbury Museum, Christchurch.
Stead, E. F., Ilam, Riccarton, Christchurch.
Steele, Professor, Canterbury College, Christchurch.
Stevenson, Dr. J., Garden Road Fendalton, Christchurch.
Strachan, J. E., M.A., B.Sc., Rangiora.
Stoddart, Miss M. O., 15 Hackthorne Road, Cashmere.
Stone, T., "Lyttelton Times," Christchurch.
Struthers, J., M.A., Boys' High School, Christchurch.
*Sylvester, S. J. H., Canterbury College, Christchurch.
Symes, Langford P., 20 May's Road, Papanui.
Tapley, J. F., Governor's Bay.
Taylor, G. J., 440 Madras Street, St. Albans, Christchurch.
Telford, Dr. T. F., Govt. Buildings, Christchurch.
Thacker, Dr. H. T. J., B.A., 43 Knowles Street, Christchurch.
Thompson, E., Canterbury Museum, Christchurch.
Tocker, Professor A. A., Canterbury College, Christchurch.
*Tripp, C. H., M.A., Timaru.
Turner, H. S. E., 36 Brown's Road, St. Albans, Christchurch.
Unwin, Dr. W. H., Timaru.
Vangioni, L. J., Akaroa.
Vincent, Spencer W., Box 91, Christchurch.
Wall, Professor A., M.A., Canterbury College, Christchurch.
Waller, F. D., B.A., 91 Papanui Road, Christchurch.
*Way, G. E., 20 Helmore's Road, Fendalton, Christchurch.
Weatherburn, Professor C. E., Canterbury College, Christchurch.
Whetter, Dr. J. P., 211 Gloucester Street, Christchurch.
Widdowson, Dr. H. L., 4 Oxford Terrace, Christchurch.
Wigram, Sir H. F., 1 Armagh Street, Christchurch.
Wild, L. J., M.A., B.Sc., F.G.S., Feilding.
Wilding, Frank S., c/o Wilding and Acland, Hereford Street, Christchurch.
Wood, W. H. J., 18 Balfour Terrace, Christchurch.
Wright, A. M., F.I.C., F.C.S., P.O. Box 617, Christchurch.

OTAGO INSTITUTE.

(* Life Members)

Adams, Professor T. D., M.A., Otago University.
Aitken, Mrs. M. W., M.Sc., Royal Botanic Gardens, Edinburgh.
Allan, R. S., M.Sc., Sedgwick Museum, Cambridge University.
Allen, Sir James, Clyde St., Dunedin.
Alexander, J. C., City Engineer's Office.
Anderson, A. W., Botanical Gardens.
Anderson, W. D., 32 Lynwood Avenue, Dunottar.
Anderson, Miss A. C., Macandrew Bay.
Angel, S., Commercial Bank of Australia, Dowling St., Dunedin.

Anscombe, E., 171 Princes Street, Dunedin.
Bain, A., B.A., Education Office, Dunedin.
Balk, O., 13 Driver Street, Maori Hill.
Barnett, Dr. L. E., Stafford Street, Dunedin.
Barr, Peter, 3 Montpelier Street.
Barron, Miss Vida, M.A., 44 Queen Street, Dunedin.
Bathgate, Alex., 84 Clyde St., Dunedin.*
Bathgate, Dr. W. J., 76 Stuart St., Dunedin.
Beal, L. O., Stock Exchange Buildings, Dunedin.
Begg, J. C., F.R.A.S., Fifield Street, Roslyn.
Begg, Mrs. A. C., 31 Ross Street, Roslyn.
Bell, A. Dillon, Shag Valley.*
Bell, Dr. Muriel, Physiology Dept., University.
Bell, Professor R. J. T., M.A., D.Sc., Otago University.
Bell, Miss C. S., M.A., Math. Dept., University of Otago.
Benham, Professor W. B., M.A., D.Sc., F.R.S., F.N.Z.Inst., Otago Museum.*
Benson, Gerald, 62 Manor Place, Dunedin.
Benson, Professor W. N., B.A., D.Sc., F.G.S., Otago University.
Birrell, W. J., care of Robin and Co., corner Castle and Hanover Streets, Dunedin.
Black, James, care of Cossens and Black, 164 Crawford Street, Dunedin.
Bowie, Dr. J. T., London Street, Dunedin.
Bowron, G. W., 426 Moray Place, Dunedin.
Brasch, H., 99 London Street, Dunedin.
Bremner, R. S., A.M.P. Buildings, Dunedin.
Brookfield, Dr. C. L., 18 Fifield St., Roslyn.
Brown, A. T., Princes Street South, Dunedin.
Brown, R. Cree, c/o Blair, Mason, Lee and Brown, Princes St.
Browne, R. A. S., care of Post Office, Morrinsville.
Burton, Miss I. H. F., 12 Alma St., Dunedin.
Butler, J. G., c/o Westport Coal Co., Dunedin.
Butterworth, C. P. M., Waverley St., Melrose.
Carter, C. L., M.Sc., A.I.C., 6 Carr Street, North East Valley.
Chamberlain, C. W., 6 Regent Road, Dunedin.*
Chapman, Sir F. R., 28 Golders Hill, Wellington.
Chapman, C. R., 53 Manor Place, Dunedin.*
Christian, E., 27 Maitland Street, Dunedin.
Christie, Thomas R., 152 Cargill St., Dunedin.
Chrystall, A. J., Colonial Mutual Buildings, Dunedin.
Clarke, C. E., F.E.S., 35 Octagon, Dunedin.
Clarke, E. S., Woodhaugh.
Cooke, S. R., School of Mines, Dunedin.
Crawford, W. J., 123 High Street, Dunedin.
Dalrymple, Rev. A. M., M.A., 33 Highgate, Roslyn.
Davidson, E., 45 Newington Avenue, Dunedin.
Davies, Rev. E., 5 Dunblane Street, Roslyn.
Davies, O. V., 109 Princes Street, Dunedin.
Don, W. G., care of Crust & Crust, Manse Street, Dunedin.
Donn, R., Training College, Dunedin.
Douglas, J. S., 12 Frederick Street, Dunedin.
Dunlop, James, Box 74, Dunedin.
Dutton, Rev. D., F.G.S., F.R.A.S., 22 Passmore Crescent, Maori Hill.*
Edgar, James, care of Victoria Insurance Company (Limited).
Evans, Dr. W., High St., Dunedin.
Farnie, Miss W., M.A., Waitaki Girls' High School, Oamaru.
Fea, W. B. M., 22 Highgate, Roslyn.
Fels, A., 31 Royal Terrace, Dunedin.
Fels, W., 84 London St., Dunedin.*
Fenwick, Sir G., "Otago Daily Times" Office.
Ferguson, Dr. Sir H. L., C.M.G., "Wychwood," Musselburgh Rise.*
Finlay, Dr. H. J., 10 Pine Hill Terrace, Dunedin.
Fitchett, Dr. F. W. B., 8 Pitt Street, Dunedin.
Fleming, T. R., M.A., LL.B., 110 Heriot Row.
Focken, Dr. C. M., B.M.E., B.Sc., Ph.D., Physics Dept., Univ. of Otago.
Fowler, H., Silveracres, Anderson's Bay, Dunedin.
Fraser, Miss M. I., Mornington.
Frye, Charles, Gasworks, Caversham.
Fyfe, H. E., 27 Richmond Street, Dunedin.
Fyfe, Miss M., B.Sc., 18 Smith St.
Gardner, W., care of H. B. Galland, Kelvin Road, North-east Valley.
Garrow, Professor J. M. E., LL.B., Victoria College, Wellington.*
Gates, D. De B., 17 Elder St.

George, Charles E., 15 Filleul St., Dunedin.
Gilkison, R., 29 Highgate, Roslyn.*
Gillman, A. J., Boys' High School.
Gray, J. A., 762 Cumberland Street, Dunedin.
Green, E. S., Education Office, Dunedin.
Guthrie, H. J., 426 Moray Place E., Dunedin.
Halsted, P. L., Royal Terrace.
Hanlon A. C., Moray Place, Dunedin.
Hart, H., 406 George Street.
Hector, Dr. C. M., Ings Avenue, St. Clair, Dunedin.
Helmkey, J. J. H., George Street, Dunedin.
Henderson, M. C., Electrical Engineer's Office, Cumberland Street, Dunedin.
Hercus, Dr. C. E., M.D., D.S.O., O.B.E., B.D.S., D.P.H., Medical School, King Street, Dunedin.
Hodson, J., 609 Castle St., Dunedin.
Holloway, Rev. J. E., D.Sc., F.N.Z. Inst., Botany Dept., Univ. of Otago.
Hooper, W. L., P.O. Box 17, Dunedin.
Howard, B., M.A., Boys' High School, Dunedin.
Howes, Miss Edith, Rawhiti Street, Sunshine.*
Howes, W. G., F.E.S., 432 George Street, Dunedin.
Hurst, J. A., B.Sc., Geol. Dept., University of Otago.
Inglis, Professor J. K. H., M.A., D.Sc., F.I.C., Otago University.
Jack, Professor R., D.Sc., Ph.D., Otago University.
Jeffrey, William, care of Brown, Ewing, and Co., Dunedin.
Joachim, Miss M. E., 4 Beaumont Road, Mornington.
Johnson, J. T., 384 King St., Dunedin.
Johnston, Dr. Owen, Invercargill.
Kay, J., 257 George Street, Dunedin.
Kaye, William T. O., Mosgiel.
Kirkland, J. C., Dental School, King St., Dunedin.
Lawson, Professor R., M.A., Litt.D., Otago University.
Lee, R., P.O. Box 363, Dunedin.
Levi, A. A., M.Sc., Club House, Moray Place, Dunedin.
Lilly, L. G., 124 London Street, Dunedin.
Lowrie, A. F., B.Sc., Mining School, University of Otago.
Lowry, J. M., Public Works Department.
Mackie, A., Test-room, Cumberland Street, Dunedin.
MacLellan, R., 67 Heriot Row.
Malcolm, Professor J., M.D., Physiology Dept., Otago University.
Mandeno, H., New Zealand Express Company's Buildings.
Marshall, Angus, B.A., Technical College.
Martin, W., B.Sc., District High School, Mosgiel.
McCarthy, A. P., 41 Roseberry N., Belleknowes.
McCurdie, W. D. R., Borough Engineer, Te Awamutu.*
McElrea, W., 138 St. David Street, Dunedin.
McIndoe, K. G., B.Sc., 549 Macandrew Road.
McFadyen, Alex., Oban St., Roslyn.
McKellar, Dr. T. G., Pitt Street, Dunedin.
McNair, J., Railway Engineer's Office, Christchurch.
Meenan, J., 79 Cargill Street, Dunedin.
Melland, E., Alport, near Bakewell, Derbyshire, England.*
Merrington, Rev. Dr., First Church Manse, Dunedin.
Milnes, J. W., 39 Lees Street, Dunedin.*
Moore, J. A., M.A., B.Sc., Training College.
Moore, Dr. S. A., Securit
Stuart Street, Dunedin apier.
Morrell, W. J., M.A., School.*
Mullin, Dr. Wm., 16 Maheno St.
Mullin, Miss K., 16 Maheno Street.
Munro, Alex., 89 Lower High St., Dunottar.
Newlands, Dr. W., 12 London Street, Dunedin.
Nicholson, E., c/o Hallenstein Bros., Dowling Street.
Northcroft, E. F., M.Sc., Biology Dept., Victoria College, Wellington.
Paterson, A. S., 9 Alva Street.
Park, Professor J., F.G.S., F.N.Z. Inst., Otago University.*
Pearcey, B. W., B.Sc., 29 Carr Street, Dunedin.
Poppelwell, D. L., Gore.
Price, W. H., care of Donald Reid and Co., Vogel Street, Dunedin.*
Reid, Miss E. N., Stafford Street.
Reid, Miss F., Stafford Street.
Richards, Right Rev. Bishop, See House, 2 Leith Rd., Maori Hill.
Riley, Dr. F. R., 346 George Street, Dunedin.
Ritchie, Dr. Russell, 400 George St., Dunedin.
Roberts, E. F., Roberts Bldgs., Stuart Street.
Roberts, Sir John, C.M.G., Littlebourne.*
Robertson, John, B.A., B.Sc., Education Office, Invercargill.

Ross, T. C., care of Ross and Glendining (Limited).
Routledge, W. R., 14 Norfolk Street, St. Clair.
Salmond, J. L., National Bank Buildings.
Sandle, Major S. G., Defence Office, Palmerston North.
Sargood, Percy R., "Marinoto," Newington.
Shacklock, J. B., Bayfield, Anderson's Bay.
Shortt, F. M., care of John Chambers and Sons, Stuart Street.
Sim, Sir William, Musselburgh Rise.*
Simpson, George, Jun., 69 Belgrave Crescent, Roslyn.
Simpson, George, sen., 111 Russell St., Dunedin.
Skinner, H. D., B.A., Museum, King Street, Dunedin.
Sligo, Alex., c/o Mills, Dick and Co., Dunedin.
Smith, C. S., "Star" Office.
Smith, J. C., care of Vernon Smith, George Street, Dunedin.*
Smith, H. McD., Dawson's Buildings, Moray Place.
Smith, Miss M., 44 Duke Street, Dun-
[illegible]ott, M.
Fitzherbert [illegible] T., care of Coulls, Somer-
Fuller, R. [illegible] Wilkie, Dunedin.
[illegible], [illegible]es, care of Kempthorne, Prosser and Co.
Steele, R. H., 69 St. David Street, Dunedin.
Stephens, O. C., c/o N.Z. Insulators, Ltd., Temuka.
Stewart, R. T., 21 Gamma Street, Roslyn.
Stewart, Hon. W. Downie, M.P., LL.B., 11 Heriot Row, Dunedin.
Stout, Sir Robert, K.C.M.G., Wellington.*
Strong, Professor, Home Science School, Otago University.
Stuckey, F., M.A., Chief Inspector of Schools, Education Office.
Tannock, D., Botanical Gardens.
Tennent, R. B., Bangor Terrace, Kew.
Theomin, D. E., 42 Royal Terrace, Dunedin.
Theomin, E., 8 Royal Terrace, Dunedin.
Thomson, W. A., Ferntree House, 75 Half-way Bush.
Thomson, Hon. G. M., F.L.S., F.N.Z. Inst., M.L.C., 99 Eglinton Road, Mornington.*
Thomson, G. S., B.Sc., 99 Eglinton Road, Mornington.
Thomson, J. S., F.C.S., care of Thomson's Limited, Police Street, Dunedin.
Tily, H. S., care of Customhouse, Dunedin.
Tucker, A. W., M.A., B.Sc., Training College.
Turnbull, Miss M. I., M.A., 449 Leith Street, Dunedin.
Turner, F. J., M.Sc, Geology Department, University.
Waite, Major F., D.S.O., Hillfoot, Waiwera South, Dunedin.
Webb, H., 83 Queen's Drive, Musselburgh.
White, Professor D. R., M.A., 83 St. David Street, Dunedin.*
White, Mr. D. R., Public Trust Office, Dunedin.
Wilkinson, H. K., 33 Royal Terrace, Dunedin.
Williams, J., B.Sc., F.C.S., Otago Boys' High School.
Williams, W. J., City Engineer's Office.
Wilson, G. T. B., 1 Bright Street, Belleknowes.
Wingfield, J. E., 655 Castle Street, Dunedin.
Yuille, Rev. Tulloch, Driver Street, Maori Hill.

HAWKE'S BAY PHILOSOPHICAL INSTITUTE.

(* Life Members)

Absolom, Mrs. J. H., Rissington.
Absolom, J. Archer, Rissington.
Armstrong, Dr. J. S., Lake Taupo.
Andersen, Miss A. M., Napier.
Armour, W. A., Napier.
Ashcroft, P., Napier.
Asher, Rev. J. A., Napier.
Beck, W. H., Napier.
Bennett, H. M., Napier.
Berry, Dr. J. A., Napier.
Bryce, G. J., Napier.
Bullock, L. E., Napier.
Chadwick, R. M., Napier.
Chambers, Bernard, Havelock.
Chambers, John, Havelock N.
Chambers, Mason, Havelock N.
Chapman, Hector, Napier.
Clapcott, G., Napier.
Clark, Dr. Arthur, Napier.
Clark, Thomas P., Eskdale.
Cottrell, Horace S., Napier.
Dinwiddie, B., Napier.
Dinwiddie, Wm., Napier.
Dixon, S. J., Hastings.

Dodds, S. C., Napier.
Duncan, R. J., Napier.
Edgar, Dr. J., Napier.
Edmundson, J. H., Napier.
Ewen, W. H., Napier.
Féré, Dr. M., Napier.
Fitzgerald, Dr. D. Napier.
Ford, A. R., Napier.
Friend, L. C., Napier.
Fussell, F. N., Napier.
Geddes, C. C., Napier.
Geddis, Trevor M., Napier.
Gilbert, Miss E. F., Napier.
Gleadow, J. E., Napier.
Goldsmith, Miss E., Napier.
Graham, Henry, Dannevirke.
Guthrie-Smith, W. H., Tutira.
Harding, J. W., Waipukurau.
Harding, W. A., Napier.
Hay, Leslie, Napier.
Henderson, W. P., Napier.
Herrick, E. J., Hastings.
Hetley, Mrs. F. A., Napier.
Hildebrandt, W. H., Napier.
Hill, Bromley, Napier.
Hill, Henry, Napier.
Hill, W. B., Taumarunui.
*Hislop, James, Napier.
Hobson, A., Napier.
Hutchinson, F. Jnr., Rissington.
Hyde, Thomas, Napier.
Kennedy, C. D., Napier.
Lambert, Thos., Wairoa.
Large, Mrs. J. S., Napier.
Leahy, Dr. J., Napier.
Lowry, T. H., Hastings.
McIlraith, Dr. J. W., Napier.
Maclean, Sir R. D. D., Napier.
Maney, C. E., Napier.
Martin, A. L., Napier.
Metcalfe, W. F., Napier.
Moore, Dr. T. C., Napier.
Moore, Dr. W. W., Napier.
Nelson, George, Hastings.
Oates, Wm., Tokomaru Bay.
Ormond, Frank, Napier.
Ormond, George, Wairoa.
Oulton, Dr. R. H., Napier.
Pallot, Alfred G., Napier.
Pallot, Mrs. W. J., Napier.
Pollock, C. F. H., Napier.
Ringland, T. H., Napier.
Sagar, Mrs. M., Napier.
Sainsbury, G. O. K., Wairoa.
Speight, H., Havelock North.
*Smith, H. J., England.
Stewart, W. B., Napier.
Stout, E. T., Napier.
Thomas, C. L., Napier.
Thomson, J. Clark, Napier.
Thomson, J. P., Napier
Tiffen, G. W., Gisborne.
Tye, Thos., Napier.
Wanklyn, H. A., Napier.
Waterworth, Dr. G., Napier.
West, E. S., Napier.
White, Wm., Napier.
Willan, T. J., Hastings.
Williams, Frederic W., N[illegible]oad,
Williams, Archdeacon H. W., [illegible]
Wilson, A. H., Napier.
Wilson, J. G., Hatuma, H.B.
Wilton, T. J., Port Ahuriri.

NELSON INSTITUTE.

Bartel, J. G., Collingwood Street.
Bett, Dr. F. A., Trafalgar Square.
Bruce, James, Britannia Heights.
Crequer, V. G., Halifax Street.
Cooke, Miss, Examiner Street.
Cullen, Father J. J., Catholic Presbytery.
Cunningham, G., Wainui Street.
Curtis, Dr. K. M., Cawthron Institute.
Davies, W. C., Cawthron Institute.
Duncan, H. R., Hardy Street.
Easterfield, Professor, Cawthron Institute.
Field, T. A. H., Rocks Road.
Gibbs, F. G., Collingwood Street.
Gibbs, Dr. S., Hardy Street.
Glasgow, J., Stoke.
Gourlay, E. S., Cawthron Institute.
Harrison, H., Cawthron Institute.
Hunter-Brown, H., Tory Street.
Hunter-Brown, Mrs. H., Tory Street.
Jamieson, Dr. J. P. S., Hardy Street.
Johnston, Dr. W. S., Hardy Street.
Kelly, R. H., 26 Hampden Street W.
Kemp, G. T., Collingwood Street.
Knapp, F. V., Alfred Street.
Maddox, F. W., Halifax Street.
May, L., Public Works, Trafalgar St.
McKay, J. G., Boys' College.
Moller, B. H., Collingwood Street.
Moncrieff, Captain M. M., The Cliffs.
Moncrieff, Mrs. M. M., The Cliffs.
Morley, E. L., Waimea Street.
Mules, Bishop, Trafalgar Square.
Parlane, Miss B., B. Sc., Cawthron Institute.
Philpott, A., Cawthron Institute.
Rigg, T., Cawthron Institute.
Rout, W., Hardy Street.
Russell, J., Sunnybank, Bronte St.
Sadlier, Bishop, Wath Brow, Brougham Street.
Smith, C. M., Conservator of Forests, Trafalgar Street.
Taylor, J., 84 Haven Road
Tillyard, Dr. R. J., Maitai Lodge.
Wardrop, J. H., Lands Department.
Wharton, Miss B. A., Maitai Bank.
Wharton, Miss W. E., Matai Bank.
Wharton, G. E., Maitai Bank.
Worley, Miss, Trafalgar Street South.

MANAWATU PHILOSOPHICAL SOCIETY.

(* Life Members)

Akers, H., Duke Street.
Bagnall, H. G., 30 Te Aweawe Street.
Barnett, Dr. E. C., M.R.C.S., M.R.C.P., Fitzherbert Street.
Batchelar, J. O., Willow Bank.
Bayly, Mrs., Patea.
Bendall, W. E., Dairy Union.
Bennett, G. H., The Square.
Bett, D. H. B., M.B., Ch.B., M.R.C.S., M.R.C.P., Broad Street.
Blackbourne, Rev. H. G., M.A., Vicarage.
Burges, A., 139 Featherston Street.
Callanan, F., Bainesse.
Cameron, W. B., 24 Russell Street.
Cameron, W. H. L., Queen Street.
Canton, H. J., Waldegrave Street.
Clausen, C. N., Rangitikei Street.
Cockayne, A. H., Wellington.
Cohen, M., Broad Street.
Collinson, L. H., The Square.
Crabb, E. H., College Street.
Cullen, Mrs., North Street.
Cunningham, G. H., Department of Agriculture.
Edwards, R., C.E., Duke Street.
Elliott, M. A., The Square.
Fitzherbert, W. L., Broad Street.
Fuller, R. A., Alexandra Street.
Gardner, Captain F. S., Bank of New Zealand, Sydney.*
Gerrand, J. B., The Square.
Grace, R. H. F., National Bank.
Graham, A. J., The Square.
Grigor, A., National Bank.
Hannay, A., care of Manson and Barr.
Hepworth, H., The Square.
Hodder, T. R., Rangitikei Street.
Holben, E. R. B., Rangitikei Street.
Holbrook, H. W. F., 84 Rangitikei Street.
Hopwood, A., Main Street.
Hughes, J. R., C.E., The Square.
Hunter, W., 15 Rangitikei Street.
Hurley, F. O., The Square.
Johnston, J., Goring, Oakhurst.
Keeling, G. W., College Street W.
Larcomb, E., C.E., Roy Street.
Larcomb, P., Roy Street.
Mahon, A., The Square.
Merton, J. L. C., LL.B., Rangitikei Street.
Miller, J., R.C.S.E., L.R.C.P.E., L.R.F.P. and S.G.
Mills, Miss C. B., M.A., Girls' High School.
Moore, Miss
Murray, J., M.A., High School.
Nash, N. H., The Square.
Needham, F., Rangitikei Street.
Oakley, F. J., Rainforth Street.
Opie, F. D., Technical School.
Oram, M. H., M.A., LL.B., Rangitikei Street.
Park, W., F.R.H.S., College Street.
Peach, Dr. C. W., M.B., C.M., Broad Street.
Pigott, Miss E., 79 College Street.
Poynton, J. W., S.M., Auckland.*
Ross, R., Ferguson Street.
Russell, W. W., Rangitikei Street.
Salmon, C. T., Assoc. in Eng., Canterbury College, Rangitikei Street.
Seifert, A., George Street.
Seifert, H., Featherston Street West.
Seifert, L., George Street.
Sheppard, F. J., Rangitikei Street.
Sim, E. Grant, Rangitikei Street.
Sinclair, N. H., Allen Street.
Smith, W. W., F.E.S., Public Reserve, New Plymouth.
Stevens, J. H., Church Street.
Stevenson, J. C., High School.
*Stowe, Dr. W. R., M.R.C.S., M.R.C.P., Linton Street.
Sutherland, A., Boundary Road.
Taylor, C., George Street.
Turner, W., Queen Street.
Welch, W., F.R.G.S., Mosman's Bay, N.S.W.
West, E. V., King Street.
Whitaker, A., Grey Street.
Wilson, Miss D., Rangitikei Street.
Wilson, Miss E. Carncot, Rangitikei Street.*
Wood, J. R., Duke Street.
Wright, A. H. M., College Street.
Young, H. L., Cuba Street.

NOTE.—This list is not up to date, no revise having been supplied of that published in vol. 57.

SERIAL PUBLICATIONS RECEIVED BY THE LIBRARY OF THE NEW ZEALAND INSTITUTE, 1928.

New Zealand.

Auckland University: *Calendar.*
Geological Survey: *Bulletins.*
Houses of Parliament: *Journals* and *Appendix.*
Journal of Agriculture.
Journal of Science and Technology.
New Zealand Employers' Federation: *Industrial Bulletin.*
New Zealand Official Year-book.
Polynesian Society: *Journal.*
Statistics of New Zealand.

Australia.

Australasian Association for the Advancement of Science: *Report.*
Australasian Institute of Mining Engineers: *Proceedings.*
Australian Antarctic Expedition, *1911-14: Reports.*
Australian Forestry Journal.
Commonwealth of Australia, Fisheries: *Parliamentary Report.*
Institute of Science and Industry of Australia: *Bulletins.*
Institution of Engineers of Australia: *Transactions; Quarterly Bulletin.*
National Research Council of Australia: *Science Abstracts.*

New South Wales.

Agricultural Department, N.S.W.: *Agricultural Gazette.*
Australian Museum, Sydney: *Records; Annual Report.*
Botanic Gardens and Government Domains, N.S.W.: *Report.*
Critical Revision of the Genus Eucalyptus.
Department of Mines and Geological Survey: *Annual Report; Mineral Resources; Bulletins.*
Linnean Society of N.S.W.: *Proceedings.*
Northern Engineering Institute of N.S.W.: *Papers.*
Public Health Department, N.S.W.: *Annual Report.*

Queensland.

Geological Survey of Queensland: *Publications.*
Queensland Naturalist.
Royal Geographical Society: *Journal.*
Royal Society of Queensland: *Proceedings.*

South Australia.

Adelaide Chamber of Commerce: *Annual Report.*
Department of Chemistry, South Australia: *Bulletins.*

Mines Department and Geological Survey of South Australia: *Mining Operations; G.S. Bulletins and Reports; Metallurgical Reports; Synopsis of Mining Laws.*
Public Library, Museum, and Art Gallery of South Australia: *Annual Report.*
Royal Society of South Australia: *Transactions and Proceedings.*

TASMANIA.

Mines Department, Hobart.
Royal Society of Tasmania: *Papers and Proceedings.*

VICTORIA.

Advisory Committee: *Report on Brown Coal.*
Department of Agriculture: *Journal.*
Field Naturalists' Club of Victoria: *Victorian Naturalist.*
Mines Department and Geological Survey of Victoria: *Annual Report; Bulletins; Records.*
Public Library, Museum, and National Art Gallery of Victoria: *Annual Report.*
Royal Society of Victoria: *Proceedings.*

WESTERN AUSTRALIA.

Geological Survey of Western Australia: *Bulletins.*
Royal Society of Western Australia: *Journal and Proceedings.*

UNITED KINGDOM.

Board of Agriculture and Fisheries: *Fishery Investigations.*
Botanical Society of Edinburgh: *Transactions and Proceedings.*
British Association for the Advancement of Science: *Report.*
British Astronomical Association: *Journal; Memoirs; List of Members.*
British Museum: *Catalogues; Guides; Scientific Reports of British Antarctic Expedition, 1910.*
Cambridge Philosophical Society: *Proceedings, Biological Reviews.*
Cambridge University Library: *Report.*
Department of Scientific and Industrial Research: *Reports.*
Dove Marine Library: *Report.*
Durham Philosophical Society: *Proceedings; Agricultural and Zoological Publications.*
Edinburgh Geological Society: *Transactions.*
Geological Department, Glasgow University: *Papers; Monographs.*
Geological Society, Glasgow: *Transactions.*
Geological Society, London: *Quarterly Journal.*
Geological Survey of Great Britain: *Summary of Progress.*
Geologists Association, London: *Proceedings.*
Handbooks, Commercial Towns, England.
H.M. Stationery Office, London: *Monthly Circular.*
Imperial Bureau of Entomology: *Review of Applied Entomology.*
Imperial Institute: *Bulletins.*

Institution of Civil Engineers: *Report.*
Leeds Geological Association: *Transactions.*
Leeds Philosophical and Literary Society: *Annual Report.*
Linnean Society: *Journal* (Botany); *Proceedings; List of Members.*
Literary and Philosophical Society, Manchester: *Memoirs.*
Literary and Philosophical Society of Liverpool: *Proceedings.*
Liverpool Biological Society: *Proceedings.*
Liverpool Geological Society: *Proceedings.*
Marine Biological Association: *Journal.*
Marlborough College Natural History Society: *Reports.*
Mercantile Guardian, London.
Mineralogical Society: *Mineralogical Magazine.*
North of England Institute of Mining and Mechanical Engineers: *Transactions; Annual Report.*
Oxford University: *Calendar.*
Royal Anthropological Institute of Great Britain: *Journal.*
Royal Botanic Gardens, Edinburgh: *Notes.*
Royal Colonial Institute: *United Empire.*
Royal Geographical Society: *Geographical Journal.*
Royal Irish Academy: *Proceedings.*
Royal Philosophical Society of Glasgow: *Proceedings.*
Royal Physical Society of Edinburgh: *Proceedings.*
Royal Scottish Geographical Society: *Scottish Geographical Magazine.*
Royal Society, Dublin: *Economic Proceedings.*
Royal Society of Edinburgh: *Proceedings; Transactions.*
Royal Society, London: *Proceedings* (Series A, B); *Phil. Trans.* (Series A, B); *Year-book.*
Royal Society of Literature: *Transactions.*
Royal Statistical Society, London: *Journal.*
Victoria Institute, London: *Journal of Transactions.*
Zoological Society of London: *Proceedings and Transactions.*

Austria.

Akademie der Wissenschaften in Wien: *Sitsungsberichte.*
Hofmuseum, Wien.
K.K. Central Anstalt für Meteorologie und Erdkunde, Vienna.
K.K. Geologischen Reichlanstalt, Vienna: *Verhandl; Jahrb.*
K.K. Naturhistorischen Hofmuseums, Vienna: *Annalen.*
K.K. Zoologisch-Botanische Gesellschaft, Vienna: *Verhandl.*

Belgium.

Académie Royale de Belgique: *Bulletins.*
Librairie Nationale d'Art et d'Histoire: *Les Cahiers belges.*
Musee Royal d'Histoire Naturelle de Belgique, Brussels: *Annales; Memoires.*
Société Geologique de Belgique, Liege: *Publications.*
Société Royale de Botanique de Belgique: *Bulletins.*
Société Royale Zoologique et Malacologique de Belgique: *Annales.*
Société Scientifique de Brussels: *Annales.*

Central Asia.

University of Central Asia, Tashkent: *Bulletin.*

China.

Science Society of China, Nanking: *Publications.*

Denmark.

Acad. Roy. de Sciences et de Lettres de Denmark: *Forhandlinger; Memoires.*
Dansk Geologisk Forening, Copenhagen: *Meddelelser.*
Dansk. Naturh. Foren. Kjöbenhavn: *Videnskabelige Meddelelser.*
Danmarks Geologiske Undersongelse, Copenhagen: *Publications.*
Kong. Dansk. Videnskab. Selskab.: *Forhandlinger; Skrifter.*
Zoological Museum, Copenhagen: *Danish-Ingolf Expedition.*

Finland.

Academia Aboensis, Abo: *Humaniora.*
Finska Vetenskaps-Societeten: *Acta; Ofersigt; Bidrag.*
Geological Commission of Finland: *Bulletin.*
Société de Geographie de Finland: *Fennia.*
Societas pro Fauna et Flora Fennica: *Meddelan; Acta.*

France.

Le Prince Bonaparte, 10 Avenue d'Jena: *Notes.*
L'Observatoire Météorologique, Paris: *Annales.*
Ministre des Travaux Publics: *Programmes des Cours.*
Musée d'Histoire Naturelle, Paris: *Bulletins.*
Société Astronomique France: *Bulletin.*
Société de Chimie Industrielle, Paris: *Chimie et industries.*
Société de Géographie: *La Géographie.*
Société des Sciences Phys. et Naturelles, Bordeaux: *Memoires, Proc. Verb.*
Société Linneene de Bordeaux: *Publications.*
Société Linneene de Normandie, Caen: *Bulletin.*
Société Zoologique de France: *Bulletin.*
University of Grenoble: *Annales section Médecine.*

Germany.

Botanische Verein der Provinz Brandenburg: *Verhandl.*
Bremer Wissenschaftlichen Gesellschaft: *Publications.*
Charles University, Prague: *Studies from Plant Physiological Laboratory.*
Der Sach Akademie der Wissenschaften, Leipzig: *Berichte; Abhandlungen.*
Deutchen Naturwissenschaften-medizinischen Verein für Bohem, Prague: *Abhandlungen; Lotos.*
Deutsches Entomologisches Museum, Berlin.
Ethnological Institute, Tubingen.
Geographie Kartographie, Leipzig: *Geographie Kartographie.*
Gesellschaft der Wissenschaften, Gottingen: *Nachrichten.*
Institut G.D. de Luxembourg, Naturelles Sciences Physiques and Mathematiques: *Archives.*

Kong. Akademie der Wissenschaften, Munchen: *Sitzungsberichte, Abhandlungen.*
Konigl. Zool. u. Anthro.-Ethno. Museum, Dresden.
Kon. Preussiche Geologischen Landesanstalt, Berlin: *Jahrbuch.*
K.K. Zentral-Anstalt für Meteorologie und Geodynamik: *Jahrb.*
Mathematische Gesellschaft, Berlin: *Sitzberichte.*
National Museum (Entomological), Prague: *Sbornik.*
Naturforschenden Gesellschaft, Freiburg: *Berichte.*
Naturhistorische Gesellschaft, Hanover: *Jahrberichte.*
Naturhistorisch Medizinischen Verein, Heidelburg; *Verhandlungen.*
Naturhistorisches Museum, Hamburg: *Mitth.*
Naturhistorische Verein der Preussischen Rheinlande und Westfalens, Bonn: *Verhandlungen; Sitzungsberichte.*
Naturwissenschaftliche Verein für Schleswig-Holstein: *Schriften.*
Oberheinischer Geologischer Verein, Tubingen.
Physikalisch-Okonomische Gesellschaft, Konisberg: *Schriften.*
Preussische Akademie der Wissenschaften, Berlin: *Sitzberichte.*
Preussische Geologische Landesanstalt, Berlin: *Jahrbuch.*
Sachsische Akademie der Wissenschaften, Leipzig: *Berichte, Abhandlungen.*
Senkenbergische Naturforschende Gesellschaft, Frankfurt-am-Main: *Berichte.*
Staats und Universitatsbibliothek, Hamburg.

Holland and Dutch East Indies.

Banka Tin: *Jaaresverslag* von de Winning.
Hollandsche Maatschappij der Wet., Harlem: *Archives Neder.*
Kon. Nederlandsch Aardrykskundig Genootschap (Royal Dutch Geographic Society): *Tidjdschrift.*
Kon. Bat. Genootschap van Wet., Batavia: *Verhand., Tijdschrift.*
Koninklijk Akademie van Wett, Amsterdam: *Proceedings, Verhandlungen.*
Koninklijke Naturkundige Vereeniging in Nederlandsch-Inde.
Mijnwesen in Nederlandsh Oest-Indie, Batavia: *Jaarbock.*
Nederlandsche Entomologische Vereeniging: *Tydschrift.*
Rijks Ethnographisch Museum, Leiden: *Verslag.*
Rijks Geologisch-Mineralogisch Museum, Leiden: *Geol. Meddelingen.*
Société Hollandaise des Sciences, Haarlem: *Sciences Exactes.*

Hungary.

Botanisches Institut Muscum and Garten, Szeged: *Folia Cryptogamica.*
Magyar Tudomanyos Akademia, Budapest: *Reports and Memoirs.*
Hungarian National Museum, Budapest: *Annales.*

Italy.

Accademia Scientifica Veneto-Trentino Istriana, Padova: *Atti.*
Giornale Botanico Italiano, Nuovo.
Laboratorio di Zoologia Generale E. Agraria, Portice, Naples.
Musei di Zoologia ed Anatomia Comp., Torino: *Bolletino.*

Reale Accademie dei Lincei, Rome: *Rendiconti.*
Reale Società Geographica, Roma: *Bollettino.*
Revista Geographica Italiana.
R. Instituto Veneto di Scienze, Lettere ed Arti, Venezia: *Atti; Memoirs.*
R. Ufficio Geologico d'Italia, Rome: *Bolletino.*
Società Africana d'Italia: *Bollettino.*
Società Botanica Italiana, Firenze: *Bollettino.*
Società Toscana di Scienze Naturali, Pisa: *Processi verbali.*

Norway.

Bergens Museum: *Aarbok; Aarberetning.*
Det Kongelige Fredriks Universitet, Christiania.
Norwegian Aurora Polaris Expedition, 1902-3.
Norwegian Meteorologischen Instituts, Kristiana: *Jahrb.*
Society of Arts and Sciences, Christiania (Oslo): *Scientific Results.*
Tromso Museum, Norway: *Annual Report, Annuals, Memoirs.*

Russia.

Biological Station, Saratov.
Comité Geologique de Russie, Leningrad: *Memoires.*
De la Société des Sciences et des Lettres de Vilno: *Travaux de l'Instit de Biologie Generale.*
Ichthyological Laboratory, Kerch: *Trudi.*
Imperial University of Youriev, Dorpat: *Revue Byzantine.*
Musée polonais d'hist. nat., Warsaw: *Zoological publications.*
Russian Entomological Society, Leningrad: *Revue Russe d'Entomologie*
Société Botanique de Pologne: *Acta Societatis.*
State University, Voronesh: *Trudi.*

Spain.

Instituto Botanico Universidade de Coimbra: *Boletin.*
Junta de Ciences Naturals de Barcelona: *Series botanica, geologica.*
Real Academia de Ciencias exactes, fisicas y naturales, Madrid: *Memorias.*

Sweden.

Botaniska Notiser, Lund.
Botaniska Tradgarden, Goteborg: *Bulletin.*
Entomologiska Foreningen, Stockholm: *Tidskrift.*
Geologiska Foreningens, Stockholm: *Forhandlingen.*
K. Universitet, Lund: *Acta.*
Kungl Svenska Vetenskapademiens, *Arkiv* for
Meteorologiske Iakttealser i Sverige.
Svenska Mosskultur Foreningen, Jonkoping: *Tidskrift.*
Svenska Naturskydds Foreningens Arsskrift, Stockholm: *Sveriges Natur.*
Svenska Sallskapet for Anthropologi och Geografi, Stockholm: *Geografiska Annaler.*
Sveriges Geologiska-Undersokning: *Arsbok.*
University of Lund: *Arsskrift.*

SWITZERLAND.

Musee d'Histoire Naturelle, Geneve.
Musei di Zoologia e Anatomia Comparata, Della R. Universita di Genova: *Bolletino.*
Naturforschende Gesellschaft, Basel: *Verhandlungen.*
Naturforschende Gesellschaft, Bern: *Mittheilungen.*
Naturforschenden Gesellschaft, Zurich: *Vierteljahrschrift.*
Societa Elvetica delle Scienze Naturali, Bern: *Atti.*
Société de Physique et d'Histoire Naturelle de Geneve.
Verhandlungen der Naturforschenden Gesellschaft in Basel.

INDIA AND CEYLON.

Agricultural Department, Calcutta: *Report on Progress of Agriculture.*
Agricultural Research Institute and College, Pusa: *Report.*
Anthropological Society, Bombay: *Journal.*
Asiatic Society of Bengal, Calcutta.
Board of Scientific Advice: *Annual Report.*
Botanic Survey of India, Sibpur, Calcutta: *Records.*
Ceylon Journal of Science.
Colombo Museum: *Spolia Zeylanica.*
Geological Survey of India: *Records and Memoirs.*
Imperial Department of Agriculture, Pusa: *Reports, Review.*

JAPAN.

Department of Agriculture and Commerce, Yokohama: *Bulletin.*
Icones Plantarum Formosanarum, Yaihoku.
Imperial Earthquake Investigation Committee, Tokyo: *Bulletin.*
Imperial Geological Survey of Japan: *Report.*
Imperial University of Tokyo: *Journal of the College of Science.*
National Research Council of Japan: *Transactions and Abstracts.*
Tohoku Imperial University, Sendai: *Science Reports.*

MALAY STATES.

Java Ethnographischen Reichsmuseums: *Katalog.*
Malay States Government Gazette.

TURKESTAN.

Scientific Society of Turkestan: *Transactions.*

EGYPT.

Ministry of Finance, Survey of Egypt, Cairo: *Bulletins.*

SOUTH AFRICA.

Cape of Good Hope Departments of Agriculture and Mines: *Reports.*
Durban Museum, Natal: *Annals.*

Geological Society of South Africa, Johannesburg: *Transactions.*
Natal Museum, Pietermaritzburg: *Annals.*
Natal Surveyor-General's Department: *Report.*
South African Association for the Advancement of Science: *South African Journal of Science.*
South African Museum: *Annals.*
Transvaal Mines Department: *Memoir.*
Transvaal Museum: *Annals.*
Union of South Africa, Mines Department Geological Survey: *Annual Reports; Memoirs.*

Canada.

Advisory Council for Scientific and Industrial Research: *Reports.*
Canadian Arctic Expedition, 1913-18: Report.
Canadian National Parks: *Booklets.*
Department of Naval Service: *Annual Report; Tide Tables.*
Department of the Interior: *Dominion Observatory Reports.*
Mines Department, Geological Survey Branch: *Memoirs; Summary Report; Museum Bulletin.*
Mines Department, Mines Branch: *Bulletins; Annual Report;* other publications.
Nova Scotian Institute of Science, Halifax: *Proceedings.*
Royal Canadian Institute, Toronto: *Transactions.*
Royal Society, Canada: *Proceedings and Transactions.*

United States.

Academy of Natural Sciences, Philadelphia: *Proceedings.*
Agricultural College Experiment Station, Michigan: *Reports; Bulletins.*
American Academy of Arts and Sciences: *Proceedings.*
American Geographical Society, New York: *Geographical Review.*
American Institute of Mining Engineers: *Transactions.*
American Journal of Philology.
American Museum of Natural History, New York: *Amer. Museum Noviates.*
American Museum of Natural History, New York: *Bulletins.*
American Philosophical Society: *Proceedings.*
Arnold Arboretum of Harvard University: *Journal.*
Astronomical Society of the Pacific, San Francisco.
Boston Society of Natural History: *Proceedings, Memoirs, etc.*
Brooklyn Institute of Arts and Sciences: *Bulletins.*
Buffalo Society of Natural Sciences: *Bulletin.*
Californian Academy of Sciences: *Proceedings.*
Californian State Fisheries Laboratory, East San Pedro.
Chicago University: *Journal of Geology.*
Cincinnati Society of Natural History: *Journal.*
Connecticut Academy of Arts and Sciences: *Transactions; Memoirs.*
Connecticut Society of Civil Engineers: *Proceedings.*
Cornell University Agricultural Experiment Station: *Memoirs; Bulletins.*

Department of Registration and Education, State of Illinois: *Bulletin.*
Experiment Station, Michigan Agricultural College, East Lansing: *Reports and Bulletins.*
Field Museum of Natural History, Chicago.
Franklin Institute: *Journal.*
Industrial and Engineering Chemistry: *Journal.*
John Crerar Library: *Annual Report.*
Johns Hopkins University, Baltimore: *Studies; Circulars; Journal.*
Journal of Geology, Chicago.
Leland Stanford Junior University: *Publications.*
Library of Congress, Washington: *Report.*
Lick Observatory, University of California.
Lloyd Library, Ohio: *Index.*
Marine Biological Laboratory, Wood's Hole, Mass: *Biol. Bulletin;*
Maryland Geological Survey: *Reports.*
Minnesota University and Geological Survey: *Agricultural Experiment Station Bulletin.*
Missouri Botanical Gardens: *Annals.*
Missouri Bureau of Geology and Mines: *Reports.*
Museum of Comparative Zoology, Harvard: *Bulletins; Annual Report; Memoirs.*
Mycological Notes, Cincinnati.
National Academy of Sciences: *Proceedings.*
National Geographic Society, Washington: *Geographical Magazine.*
National Research Council: *Reprints and Circulars.*
New York Academy of Sciences: *Annals.*
New York Botanic Garden: *Bulletin; Journal.*
New York State College of Agriculture.
New York State Library: *Museum Memoirs* and *Bulletins.*
Ohio Journal of Science.
Ohio State University: *Bulletin.*
Pennsylvania State College: *Publications.*
Puget Sound Biological Station, University of Washington.
Rochchester Academy of Sciences: *Proceedings.*
Smithsonian Institution and U.S. National Museum: *Annual Report; Miscellaneous Collections; Contributions to Knowledge; Bulletins; Contributions from U.S. National Herbarium.*
State University of New Mexico, Albuquerque: *Publications.*
Tufts College: *Studies (Scientific Series).*
U.S. Coast and Geodetic Survey: *Annual Report.*
U.S. Department of Agriculture: *Journal of Agricultural Research; Monthly List of Publications*; *Year Book.*
U.S. Department of Commerce and Labour: *Bulletin.*
U.S. Department of Agriculture, Bureau of Biological Survey: *North American Fauna; Bulletins.*
U.S. Geological Survey: *Annual Report; Professional Papers; Mineral Resources; Bulletins; Water-supply Papers.*
U.S. National Research Council: *Bulletins.*
United States Naval Observatory: *Annual Report.*
University of California: *Bulletin of Department of Geology.*
University of Kansas: *Science Bulletin.*

University of Michigan: *Papers.*
University of Missouri: *Bulletins; Studies.*
University of Oklahoma, Norman: *Proceedings, Bulletins.*
University of Oregon.
University of Washington.
Virginia Geological Survey, Charlottesville: *Publications.*
Wagner Free Institute of Science: *Transactions.*
Washington Academy of Sciences: *Proceedings.*
Wisconsin Academy of Sciences: *Transactions.*

Argentine.

Academia Nacional de Ciencias: *Boletin.*
Argentine Society of Geographical Studies, Buenos Aires; *Gaea.*
Ministeria da Agricultura Industria e Commercio: *Monographs; Bulletin.*
Sociedad Cientifica Argentina: *Anales.*
Universidad Nacionale de la Plata: *Revista; Boletin; Contributions estudio de la Ciencias.*

Brazil.

Da Escola Agricultura Rio de Janeiro.
Museo Nacional Rio de Janiero: *Archives.*
Observatorio de Rio de Janeiro.

Mexico.

Instituto Geologico de Mexico: *Anales.*

Peru.

Cuerpo de Ingenieros de Mines del Peru: *Boletin.*

Hawaii.

Bishop Museum: *Memoirs.*

Philippines.

Bureau of Science: *Philippine Journal of Science.*

Tahiti.

Société d'Études Oceanniennes: *Bulletin.*

LIST OF INSTITUTIONS

TO WHICH

THE PUBLICATIONS OF THE INSTITUTE ARE PRESENTED BY THE GOVERNORS OF THE NEW ZEALAND INSTITUTE.

Honorary Members of the New Zealand Institute.

New Zealand.

Alexander Turnbull Library, Bowen Street, Wellington.
Cabinet, The Members of, Wellington.
Executive Library, Wellington.
Forestry Department, Wellington.
Free Public Library, Auckland.
,, Christchurch.
,, Dunedin.
,, Invercargill.
,, Wellington.
Library, Auckland Institute, Auckland.
,, Auckland Museum, Auckland.
,, Biological Laboratory, Canterbury College, Christchurch.
,, Biological Laboratory, University College, Auckland.
,, Biological Laboratory, University of Otago, Dunedin.
,, Biological Laboratory, Victoria University College, Wellington.
,, Canterbury College, Christchurch.
,, Canterbury Museum, Christchurch.
,, Canterbury Public Library, Christchurch.
,, Cawthron Institute, Nelson.
,, Department of Agriculture, Wellington.
,, Dunedin Athenaeum.
,, General Assembly, Wellington (2 copies).
,, Hawke's Bay Philosophical Institute, Napier.
,, Manawatu Philosophical Society, Palmerston North.
,, Nelson College.
,, Nelson Institute, Nelson.
,, New Zealand Geological Survey.
,, New Zealand Institute of Surveyors.
,, New Zealand Institute, Wellington.
,, Otago Institute, Dunedin.
,, Otago Museum, Dunedin.
,, Otago School of Mines, Dunedin.
,, Philosophical Institute of Canterbury, Christchurch.
,, Polynesian Society, Wellington.
,, Portobello Fish-hatchery, Dunedin.
,, Reefton School of Mines.
,, Southland Museum, Invercargill.
,, Thames School of Mines.
,, University College, Auckland.
,, University of Otago, Dunedin.

Library, Victoria University College, Wellington.
„ Waihi School of Mines, Waihi.
„ Wanganui Museum.
„ Wellington Philosophical Society.

Austria.

Akademie der Wissenschaften in Wien.
Intendanz des Naturhistorische Hofmuseums, Vienna.
K.K. Central-Anstalt für Meteorologie und Erdmagnetismus, Vienna.
K.K. Geologische Reichsanstalt, Vienna.
Zoologisches Botanisches Gesellschaft, 111 Mechelgasse 2, Vienna.

Belgium.

Acadèmie Royal des Sciences, des Lettres, et des Beaux-Arts de Belgique, Brussels.
La Société Royale de Botanique de Belgique, Brussels.
Musée Royal d'Histoire Naturelle de Belgique, Brussels.
Société Geologique de Belgique, Liege.
Société Scientifique de Bruxelles, 2 Rue du Manège, Louvain.

Central Asia.

University of Central Asia, Tashkent, c/o USSR Society of Cultural Relations with foreign countries, 6 Malaya Nikitskaya, Moscow 69.

China.

Science Society of China, Nanking.

Denmark.

Danmarks Geologiske Undersoegelse, Copenhagen
Dansk Geologisk Forening, Copenhagen.
Natural History Society of Copenhagen.
Royal Danish Academy of Sciences and Literature of Copenhagen.

Finland.

Abo Akademi, Abo.
Finska Vetenskats Societies, Helsingfors.
Geol. Kommissionen i Finland, Helsingfors.
Société de Geographie de Finlands, Helsingfors.

France.

Bibliothèque Nationale, Paris.
Musée d'Histoire Naturelle, Paris.
Société Lenneene de Bordeaux.
Société Linneene de Normandie, Caen.
Société Zoologique de France, Paris.
Société de Chimie Industrielle, 49 Rue de Mathurins, Paris.
Société des Sciences Phys. et Naturelles, Bordeaux.
University of Grenoble.

Germany.

Biologisches Zentralblatt, Berlin, Dahlem.
Botanischer Verein der Provinz Brandenburg, Berlin.
Bremer Wissenschaftlichen Gesellschaft.
Deutsches Entomologisches Museum, Gossler-Str. 20, Berlin, Dahlem.
Ethnological Institute, Tubingen.
Gesellschaft der Wissenschaften, Gottingen.
Institut G.D. de Luxembourg, Naturelles Sciences Physiques and Mathematiques.
Kong. Akademie der Wissenschaften, Munchen.
Königliche Physikalisch-Oekonomische Gesellschaft, Konigsberg, E. Prussia.
Königliches Zoologisches und Anthropologisch-Ethnographisches Museum, Dresden.
Mathematische Gesellschaft, Berlin.
Naturhistorischer Verein, Bonn.
Naturhistorischer Museum, Hamburg.
Naturwissenschaftlicher Verein, Bremen.
Naturwissenschaftlicher Verein, Frankfurt-an-der-Oder.
Naturforschenden Gesellschaft, Freiburg.
Naturhistorische Gesellschaft, Hanover.
Naturhistorisch-Medizinschen Verein, Heidelburg.
Oberheinischer Geologischer Verein, Tubingen.
Preussische Akademie der Wissenschaften, Berlin.
Preussische Geologische Landesanstalt, Berlin.
Prussische Bibliothek, Berlin.
Rautenstrauch-Joest-Museum (Städtisches Museum für Völkerkunde) Cologne.
Redaction des Biologischen Centralblatts, Erlangen.
Sachsische Akademie der Wissenschaften, Leipzig.
Senckenbergische Naturforschende Gesellschaft, Frankfurt-am-Main.
Staats und Universitatsbibliothek, Hamburg.
Staatliches Forschungsinstitut für Volkerkunde, Leipzig.
Verein für Vaterländische Naturkunde in Würtemburg, Stuttgart.
Zoological Museum der Universitat, No. 4 Invalidenstr 43, Berlin.

Great Britain.

Athenaeum Subject Index to Periodicals, c/o National Library of Wales, Aberystwyth.
Bodleian Library, Oxford University.
British Association for the Advancement of Science, Burlington House, London W1.
British Museum Library, London.
" Natural History Department, South Kensington London S.W.
Cambridge Philosophical Society, Cambridge University.
Clifton College, Bristol, England.
Dominions Office, Downing St., London, S.W.1.
Durham Philosophical Society.

Geological Magazine, Publishers 34-36 Margaret St., Cavendish Square, London.
Geological Society, Glasgow.
" Burlington House, London, W.1.
Geological Survey of the United Kingdom, Jermyn St., London, S.W.
Geological Survey Office, 14 Hume Street, Dublin.
Geologists' Association, University College, Gower St., London.
High Commissioner for New Zealand, Strand, London, W.C.2.
Imperial Bureau of Entomology, 89 Queen's Gate, London, S.W.7.
Imperial Institute, South Kensington, London, S.W.7.
Institution of Civil Engineers, Great George St., Westminster, London, S.W.
International Catalogue of Scientific Literature, 34 Southampton Street, Strand, London.
Leeds Geological Association, Sunnyside, Crossgate, Leeds.
Linnean Society, Burlington House, Piccadilly, London.
Liverpool Literary and Phil. Society, University, Liverpool.
Literary and Philosophical Society, Manchester.
Liverpool Biological Society, University, Liverpool.
Marine Biological Association of the United Kingdom, Plymouth.
Natural History Society, 207 Bath St., Glasgow.
Nature, The Editor of, Macmillan and Co., Publishers, London.
Norfolk and Norwich Naturalist Society, The Castle Museum, Norwich.
North of England Institute of Mining and Mechanical Engineers, Newcastle-upon-Tyne.
Patent Office Library, 25 Southampton Street. London W.C.
Philosophical Society of Glasgow, Bath St., Glasgow.
Royal Anthropological Institute of Great Britain and Ireland 52 Upper Bedford Place, Russell Sq., London, W.C.1.
Royal Botanic Garden Library, Edinburgh.
Royal Colonial Institute, Northumberland Avenue, London, W.C.
Royal Gardens, Kew, England.
Royal Geographical Society, Kensington Gore, London S.W.
Royal Institution, Colquitt Street, Liverpool.
Royal Irish Academy, 19 Dawson Street, Dublin.
Royal Physical Society, Synod Hall, Castle Terrace, Edinburgh.
Royal Scottish Geographical Society, Synod Hall, Castle Terrace, Edinburgh.
Royal Society, Dublin.
" " Edinburgh.
" " Burlington House, London, W.1.
Royal Society of Literature of the United Kingdom, Bloomsbury Sq., London.
Royal Statistical Society, 9 Adelphi Terrace, Strand, London, W.C.2.
University Library, Cambridge, England.
" Edinburgh.
Victoria University, Christie Library, Manchester.
Victoria Institute, 1 Central Bldgs., Westminster, London.
Wheldon and Wesley, Ltd., London (Agents).
Zoological Society, Regents Park, London, N.W.

Holland.

Bureau Koninklijk Nederl. Aardrijkskundig Genootschap, 28 Saxen-Weimarlaan, Amsterdam.
Hollandsche Maatschappij der Wet., Harlem.
Koninklijk Akademie van Wett, Amsterdam.
Musée Teyler, Haarlem.
Netherlands Entomological Society, Koloniaal Instituut, 62 Mauritskade, Amsterdam.
Rijks Geologisch-Mineralogisch Museum, Leiden.

Hungary.

Botanisches Institut Museum and Garten, Szeged.
Magyar Tudomanyos Akademia, Budapest.
Zoological Department, National Museum, Budapest.

Italy.

Accademia Scientifica Veneto-Trentino Istriana, Padova.
Biblioteca ed Archivio Tecnico, Rome.
Laboratorio di Zoologica e Agraria, Portici, Naples.
Museo Civice di Storia Naturale, Genova.
Museo di Zoologia e di Anatomia Comparata della R. Universita, Turin.
R. Accademia dei Lincei, Rome.
R. Accademia di Scienze, Lettre, ed Arti, Modena.
R. Instituto Veneto di Scienze, Lettere ed Arti, Venezia.
R. Ufficio Geologico, Rome.
Società Africana d'Italia, Naples.
Società Botanica Italiana, Florence.
Società Geografica Italiana, Villa Celimontana, Piazza della Navicella, Rome (24).
Società Toscana di Scienze Naturali, Pisa.
Stazione Zoologica di Napoli, Naples.

Mexico.

Instituto Geologico, Mexico.

Norway.

Adviser of Norwegian Fisheries, Postboks 226, Bergen.
Bergens Museum, Bergen.
Tromso Museum, Norway.
University of Christiania.

Poland.

Musée polonais d'hist. nat., Warsaw.

Russia.

Biological Station, Saratov.
Comité Geologique de Russie, Leningrad.

Ichthyological Laboratory, Kerch, c/o USSR Society of Cultural Relations with foreign countries, Malaya Nikitskaya, Moscow 69.
Kiefskoie Obshchestvo Iestestvo-Ispytatelei (Kief Society of Naturallists), 37-10 Ul Korolenko, Kiev U.S.S.R.
Russian Entomological Society, Zoological Museum of the Academy of Sciences, Leningrad, USSR.
State University, Veronesh, c/o USSR Society of Cultural Relations with foreign countries, Malaya Nikitskaya, Moscow 69.

Spain.

Instituto Botanico Universidade de Coimbra.
Junta de Ciencies Naturals, Barcelona, Apartado 593.
Real Academia de Ciencias exactes, fisicas y naturales, Madrid.

Sweden.

Botaniska Tradgarden, Goteborg.
Entomologiska Foreningen, Stockholm.
Geological Survey of Sweden, Stockholm.
Geologiska Foreningen, Stockholm.
K. Universitet, Lund.
Royal Academy of Science, Stockholm.
Svenska Mosskultur Forneingen, Jonkoping.
Svenska Naturskydds Foreningen, Stockholm.
Svenska Sallskapet fur Anthropologi och Geografi, Stockholm.
Universitetsbiblioteket, Uppsala.

Switzerland.

Musci di Zoologia e Anatomia Comparata della R. Universita di Genova.
Naturforschende Gesellschaft, Basel; *Verhandlungen.*
Naturforschende Gesellschaft (Sociètè des Sciences Naturelles), Bern.
Naturforschenden Gesellschaft, Zurich; *Vierteljahrschrift.*
Societe de Physique et d'Histoire Naturelle de Geneve.

India.

Anthropological Society, Bombay.
Asiatic Society of Bengal, Calcutta.
Botanic Survey of India, Sibpur, Calcutta.
Colombo Museum, Ceylon.
Geological Survey of India, Calcutta.
Imperial Department of Agriculture, Pusa: *Reports, Review.*

Malay States.

Raffles Museum, Singapore.

Japan.

College of Science, Imperial University of Japan, Tokyo.
Imperial Geological Survey of Japan, Tokyo.
Ohara Institute for Agriculture, Japan.

Java.

Kon. Bat. Genootschap van Wet., Batavia.
Society of Natural Science, Batavia

South Africa.

Durban Museum, Natal.
Free Public Library, Cape Town.
Geological Society of South Africa, Johannesburg.
Geological Survey, Union of South Africa, Pretoria.
Natal Museum, Pietermaritzburg.
Rhodesia Museum, Bulawayo, South Africa.
South African Association for the Advancement of Science, Cape Town.
South African Museum, Cape Town.

British North America.

Geological and Natural History Survey of Canada, Ottawa.
Hamilton Scientific Association, Hamilton, Canada.
Institute of Jamaica, Kingston, Jamaica.
Library, Department of Agriculture, West Block, Ottawa, Canada.
Library, Advisory Research Council, Ottawa, Canada.
Natural History Society of New Brunswick, St. John's.
Nova-Scotian Institute of Natural Science, Halifax.
Royal Canadian Institute, Toronto.

United States of America.

Academy of Natural Sciences, Buffalo, State of New York.
" Davenport, Iowa.
" Library, Philadelphia.
" San Francisco.
American Academy of Arts and Sciences, Boston.
American Engineering Societies' Library, 29 West 39th Street, New York.
American Geographical Society, New York.
American Journal of Science (Editors), Yale University, New Haven, Conn.
American Museum of Natural History, New York, *Bulletins* only.
American Philosophical Society, Philadelphia.
Arnold Arboretum, Harvard University, Jamaica Plains, U.S.A.
Astronomical Society of the Pacific, San Francisco.
Boston Society of Natural History.
Brooklyn Botanical Gardens, New York.
California State Fisheries Laboratory, East San Pedro.
Chemical Abstracts, Ohio State University, Columbus, Ohio.
Cincinnati Society of Natural History.
Connecticut Academy, New Haven.
Department of Agriculture, Library, Washington, D.C.
Department of Botany, University of Montana.
Eaton Memorial Library, Tufts College, Mass.
Experiment Station, Michigan Agricultural College, East Lansing.

Field Museum of Natural History, Chicago.
Franklin Institute, Philadelphia.
Johns Hopkins University, Baltimore.
Journal of Geology (Editors), University of Chicago, Chicago, Ill.
Kansas University, U.S.A.
Leland Stanford Junior University, California.
Library, Bureau of Science, Manila.
Lloyd Library, 309 West Court St., Cincinnati, Ohio.
Marine Biological Laboratory, Wood's Hole, Mass.
Missouri Botanical Gardens, St. Louis, Mo.
Museum of Comparative Zoology, Cambridge, Mass.
National Academy of Sciences, B. and 21st Streets, Washington, D.C.
National Geographic Society, Washington, D.C.
New York Academy of Sciences, 77th Street and Central Park West, New York.
New York Botanical Garden, Bronx Park, New York City.
New York State College of Agriculture, Ithaca, New York.
New York State Library, Albany, New York.
Ohio Academy of Sciences, Ohio, Columbus.
Pennsylvania State College.
Princeton University, U.S.A.
Puget Sound Biological Station, Univ. of Washington.
Rochester Academy of Sciences.
Smithsonian Institute, Washington, D.C.
State University of New Mexico, Albuquerque.
United States Geological Survey, Washington.
University of California, Berkeley, U.S.A.
University of Illinois, Urbana, Illinois.
University of Kansas.
University of Michigan.
University of Minnesota, Minneapolis.
University of Missouri, Columbia.
University of Oklahoma, Norman.
University of Oregon.
University of Washington, Seattle.
Virginia Geological Survey, Charlottesville.
Wagner Free Institute of Science of Philadelphia.
Wisconsin Academy of Sciences, Arts, and Letters, Madison.

Argentine Republic.

Academia Nacional de Ciencias, Cordoba.
Argentine Society of Geographical Studies, Buenos Aires.
Direccion General de Minas, Geologia e Hidrologia Buenos Aires.
Museo Nacional de Historia Natural de Buenos Aires, Casilla del Correro.
Sociedad Cientifica Argentina, Buenos Aires.

Brazil.

Escola de Minas, Rio de Janeiro.
Museu Paulista, Sao Paulo.

Uruguay.

Museo Nacional. Monte Video.

Hawaii.

Bernice Pauahi Bishop Museum, Honolulu.
National Library, Honolulu.
Volcano Observatory, Kilauea, Hawaii Islands.

New South Wales.

Agricultural Department, Sydney.
Australasian Association for the Advancement of Science, Sydney.
Australian Museum Library, Sydney.
Consulate-General of the Czecho-Slovak Republic, Sydney.
Department of Mines, Sydney.
Engineering Institute of New South Wales, Watt Street, Newcastle.
Institution of Engineers, Marcleay House, 16 College St., Sydney.
Library, Botanic Gardens, Sydney.
Linnean Society of New South Wales, Sydney.
Public Library, Sydney.
Royal Society of New South Wales, Sydney.
University Library, Sydney.

Queensland.

Geological Survey Office, Brisbane.
Queensland Museum, Brisbane.
Royal Society of Queensland, Brisbane.

South Australia.

Public Museum and Art Gallery of South Australia, Adelaide.
Royal Society of South Australia, Adelaide.
University Library, Adelaide.

Tasmania.

Mines Department, Hobart.
Public Library of Tasmania, Hobart.
Royal Society of Tasmania, Hobart.

Victoria.

Advisor Council of Science and Industry, 314 Albert Street, East Melbourne.
Australian Institute of Mining Engineers, Melbourne.
Commonwealth Institute of Science and Industry, Danks Buildings, 391 Bourke Street, Melbourne.
Field Naturalists' Club, Melbourne.
Geological Survey of Victoria, Melbourne.
Legislative Library, Melbourne.
National Herbarium of Victoria, South Yarra.
National Museum, Melbourne.
Royal Society of Victoria, Melbourne.
Public Library, Melbourne.
University Library, Melbourne.

Western Australia.

Government Geologist, Geological Survey Office, Box L 906, G.P.O., Perth.
Royal Society, Perth.

GENERAL INDEX.

INDEX OF AUTHORS.

FERGUSON & OSBORN LTD., 202 LAMBTON QUAY, WELLINGTON, N.Z.

TRANSACTIONS

AND

PROCEEDINGS

OF THE

NEW ZEALAND INSTITUTE

VOL. 59.

(Quarterly Issue)

EDITED AND PUBLISHED UNDER THE AUTHORITY OF THE BOARD
OF GOVERNORS OF THE INSTITUTE

Part 1 (pp. 1-212) issued 31st May, 1928
Part 2 (pp. 213-428) issued 31st August, 1928
Part 3 (pp. 429-662) issued 30th November, 1928
Part 4 (pp. 663-1024) issued 28th March, 1929

Wellington, N.Z.
FERGUSON & OSBORN, LTD., 202 LAMBTON QUAY.
Wheldon & Wesley, Ltd., 2, 3 & 4 Arthur St., New Oxford St., London, W.C.2.

NEW ZEALAND INSTITUTE.

NOTICE TO MEMBERS.

THE publications of the New Zealand Institute consist of—

1 Transactions, a yearly volume of scientific papers read before the local Institutes. This volume is of royal-octavo size.

2. Proceedings, containing report of the annual meeting of the Board of Governors of the New Zealand Institute, abstracts of papers dealing with New Zealand scientific matters and published elsewhere, list of members, &c. The *Proceedings* are of the same size as the *Transactions,* and are bound up with the quarterly numbers of *Transactions* supplied to members.

3. Bulletins. Under this title papers are issued from time to time which for some reason it is not possible to include in the yearly volume of *Transactions.* The bulletins are of the same size and style as the *Transactions,* but appear at irregular intervals, and each bulletin is complete in itself and separately paged. The bulletins are not issued free to members, but may be obtained by them at a reduction on the published price.

LIBRARY PRIVILEGES OF MEMBERS.—Upon application by any member to the Librarian of the New Zealand Institute or of any of the affiliated Societies such works as he desires to consult which are in those libraries will be forwarded to him, subject to the rules under which they are issued by the Institute or the Societies. The borrower will be required to pay for the carriage of the books. For a list of the serial publications received by the Library of the New Zealand Institute during 1928, see pp. 986-995.

ADDRESSES OF MEMBERS.—Members are requested to notify the Secretary of any change of address, so that the same may be noted in the List of Members.

MEMORANDUM FOR AUTHORS OF PAPERS.

The attention of authors is particularly directed to the following instructions, the observance of which will greatly aid the work of both Editor and printer. It is of importance that in typewritten as well as other copy ample space should be left between the lines.

1. All papers must be typewritten, unless special permission to send in written papers has been granted by the Editor for the time being. Wide spacing between the lines and ample margin should be left.

2. The author should read over and correct the copy before sending it to the Editor of the *Transactions.*

3. A badly arranged or carelessly composed paper will be sent back to the author for amendment. It is not the duty of an editor to mend either bad arrangement or defective composition.

4. In regard to underlining of words, it is advisable, as a rule, to underline only specific and generic names, titles of books and periodicals, and foreign words.

5. In regard to specific names, the International Rules of Zoological Nomenclature and the International Rules for Botanical Nomenclature must be adhered to.

6. Titles of papers should give a clear indication of the scope of the paper, and such indefinite titles as, *e.g*, "Additions to the New Zealand Fauna" should be avoided.

7. Papers should be as concise as possible.

8. Photographs intended for reproduction should be the best procurable prints, unmounted and sent flat.

9. *Line Drawings.*—Drawings and diagrams may be executed in line or wash. If drawn in line—*i.e.*, with pen and ink—the best results are to be obtained only from good, firm, black lines, using such an ink as Higgin's liquid India ink, or a freshly mixed Chinese ink of good quality, drawn on a smooth surface, such as Bristol board. Thin, scratchy, or faint lines must be avoided. Bold work, drawn to about twice the size (linear) of the plate, will give the best results. Tints or washes may not be used on line drawings, the object being to get the greatest contrast from a densely black line drawn on a smooth, white surface.

10. *Wash Drawings.*—If drawing in wash is preferred, the washes should be made in such water-colour as lamp-black, ivory black, or India ink. These reproduce better than neutral tints, which inclines too much to blue in its light tones. High lights are better left free from colour, although they may be stopped out with Chinese white. As in

…vin… …ace should be used (the grain of most draw-
… …n the print with bad effect), and well-modelled
… …ve satisfactory results.

… Drawings.—The printed plate will not exceed 7¼in. … …wings for plates may be to this size, or preferably a … maintaining the same proportion of height to width of plate. …hen a number of drawings are to appear on one plate they should be neatly arranged and if numbered or lettered in soft pencil the printer will mark them permanently before reproduction. In plates of wash drawings, all the subjects comprising one plate should be grouped on the same sheet of paper or cardboard, as any joining-up shows in the print. Text-figures should be drawn for reduction to a width not exceeding 4½in. If there are a number of small text-figures they should be drawn all for the same reduction, so that they may be arranged in groups.

12. *Maps.*—A small outline map of New Zealand is obtainable at a low price from the Lands and Survey Department, Wellington, upon which details of distribution, &c., can be filled in according to the instructions given above for line drawings.

13. *Citation.*—References may be placed in a list at the end of article or arranged as footnotes. The former method is preferabl… long papers. In the list references are best arranged alphabeti… reference in the text being made by writing after the author's … as it occurs, the year of publication of the work, adding, if nece… a page number, and enclosing these in parentheses, thus: "B… …m (1915, p. 176)." Example of forms of citation for alphabetical list:—

BENHAM, W. B., 1915. Oligochaeta from the Kermadic Islands, *Trans. N.Z. Inst.*, vol. 47, pp. 174-85.

PARK, J., 1910. *The Geology of New Zealand*, Christchurch, Whitcombe and Tombs.

When references are not in alphabetical order the initials of the author should precede the surname, and the year of publication should be placed at the end. Care should be taken to verify the details of all references—date, pages, &c.—and initials of authors should be given.

14. In accordance with a resolution of the Board of Governors, authors are warned that previous publication of a paper may militate against its acceptance for the *Transactions.*

15. In ordinary cases twenty-five copies of each paper are supplied gratis to the author, and in cases approved of by the Publication Committee fifty copies may be supplied without charge. Additional copies may be obtained at cost price.

CONTENTS.

CHEMISTRY.

GEOLOGY.